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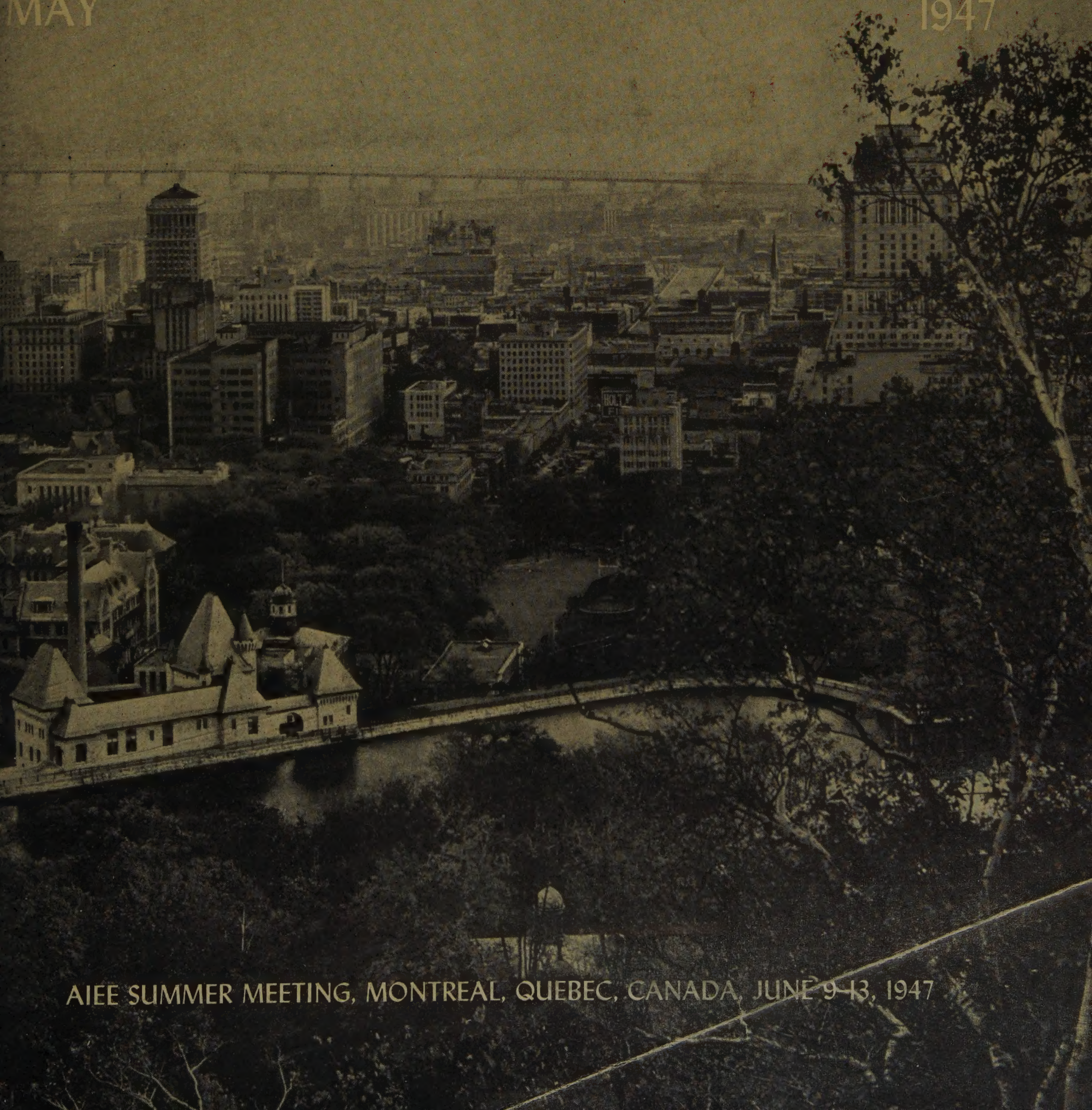

AIEE SUMMER MEETING, MONTREAL, QUEBEC, CANADA, JUNE 9-13, 1947

UNFINISHED BUSINESS

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SPECIFICATIONS
THIS EQUIPMENT IS DESIGNED TO OPERATE AT 115V-AC-60 CYCLES
This equipment is designed to operate at
115 V-AC
60 cycles
As a protection against voltage fluctuations a CONSTANT VOLTAGE TRANSFORMER has been built-in as a component part of this equipment. Rated performance will therefore be maintained at all times, regardless of input voltage fluctuations as great as ±15%.

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Rural Carrier Telephony

Field tests of carrier telephony on power lines were conducted in the rural districts near Jonesboro, Ark., and Selma, Ala., during the early part of 1946. Operating experience obtained from these installations has enabled the development of a commercial rural carrier system for application on power lines and telephones. Several such systems are now in operation and others are being installed.

CONVENTIONAL methods of extending rural telephone service include open wires using long span construction on separate poles or open wires on poles used jointly to provide power and telephone service. The possibility of supplying telephone service over power lines to rural customers in sparsely settled areas was first considered seriously by engineers of Bell Telephone Laboratories in 1936. A brief investigation at that time indicated that the transmission of voice frequencies directly over the power wires was impracticable because of the high transmitting power necessary to override ambient noise levels. Since static and power system noise generally decrease with increasing frequency, attention was thereafter focussed on the possibilities of carrier-current methods. The project was abandoned during the war, but was revived early in 1945.

A system known as the *M1* carrier telephone system has been developed and is being manufactured by the Western Electric Company.

In applying the carrier system it is necessary to modify the power line to enable it to be used as a medium for carrier transmission, to provide terminal equipment for the transmitting and receiving of the carrier signals, and to provide means for coupling the terminal equipment to the power lines. Figure 1 illustrates the arrangement of this equipment on the power line.

This double-side-band amplitude-modulated carrier system, operating in the 150–455-kc band, can provide a maximum of six 2-way telephone channels over a given section of power line. Each channel can be considered equivalent to a voice frequency telephone pair and can serve as many parties as requirements and ringing facilities at the central office permit. For each channel used, a separate common carrier terminal is required. Provision can be made for connecting the common terminal over a voice frequency circuit to the regular rural line equipment in any type of dial, common battery, or magneto exchange. Operating procedures on all types of calls are the same as for rural wire lines in the same exchange.

The 120-volt 60-cycle power supply for the subscriber carrier terminal is obtained from a convenience outlet at the subscriber's premises. The power requirements of the subscriber terminals range from 7 watts in the stand-by condition to a maximum of 25 watts in the talking condition.

Common carrier terminals can be installed in central offices in cases where proximity of the central offices to the power lines permits. In other situations the terminal is installed at a convenient point on or adjacent to the power line and the 120-volt 60-cycle power supply is obtained from the power system through a conventional service connection. Power requirements for the common carrier terminal range from 16 watts per carrier terminal in the stand-by condition to about 30 watts per carrier terminal in the talking condition.

TREATMENT OF POWER SYSTEM

The transmission characteristics of a power system at carrier frequencies are quite different from those at 60 cycles. This is due primarily to the fact that the lines are "electrically long" at carrier frequencies, that is, the physical length of the lines may be many times the carrier wave length, whereas at 60 cycles the line length is a very small fraction of the transmitted wave length. Furthermore, whereas power line carrier systems heretofore have been operated over long relatively "smooth" transmission lines, power distribution systems involve many serious electrical irregularities.

In rural areas, with which the power line carrier project mainly is concerned, the upper wire is a phase wire operating at a 60-cycle voltage of about 7 kv above ground, and the lower wire is a neutral wire which generally is grounded at frequent intervals. The network usually is characterized by many branches and taps over which telephone service may or may not be required. A section of rural power line which is to be used for carrier transmission can be considered as consisting of a main line with a number of taps of different lengths connected to it. Each tap, irrespective of length, represents a source of impedance irregularity, and loss to carrier transmission over the main line. To minimize the effect of these taps on the carrier transmission and, to provide for dividing the power lines into

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Based upon two papers: 47-80, "A Carrier Telephone System for Rural Service," by J. M. Barstow, and 47-81, "Application of Rural Carrier Telephone System," by E. H. B. Bartelink, L. E. Cook, F. A. Cowan, and G. R. Messmer. Both papers were presented at the AIEE winter meeting, New York, N. Y., January 27–31, 1947, and are scheduled for publication in AIEE *TRANSACTIONS*, volume 66, 1947.

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carrier sections, chokes are used in series with the phase wire of taps at the point where they connect to the main line, and in series with the phase wire of the main line at the ends of carrier sections. Three general types of chokes are provided; isolating chokes, tap chokes, and transmission chokes.

The 60-cycle ratings of the chokes have been selected with the objective of causing a minimum effect on the operation of the power system (and at same time obtaining the required carrier frequency characteristics). The maximum impedance of any of the chokes is about $0.9 + j\ 4.5$ ohms at 60 cycles. In some cases three or four chokes may be placed in series with a phase wire between the power source and loads thereby increasing the 60-cycle line impedance sufficiently that it should be considered in short-circuit current or voltage regulation studies on the system. The resistive component of the impedance of the chokes is relatively low and, therefore, the energy loss will be small.

The following summary describes the treatment applied to the power network in order to provide satisfactory carrier transmission. The treatment is illustrated in Figure 1:

1. Main line used for carrier transmission. Always terminated at carrier frequencies in approximately characteristic impedance (500 ohms) at each end.
Isolating choke coils (10 millihenrys) applied at ends as required. Tap chokes (2.5 millihenrys) may be used when 60-cycle current rating is sufficient.

2. Taps not used for carrier transmission.
Choke coil always applied at tap point. Tap chokes normally used, but isolating choke may be used if 60-cycle current rating of the tap choke is insufficient for the tap.

3. Taps used for carrier transmission.
Always terminated at carrier frequencies in approximately characteristic impedance at, or beyond, the location of last subscriber.
Transmission choke (0.6 millihenry or 0.3 millihenry) used at each tap point. Exception: At a point where the loss caused by the insertion of a transmission choke coil would produce a loss to the connected stations such that the total loss exceeds the limiting total loss, the transmission choke coil may be omitted for purposes of equalizing losses. (See tap on north tap at 8-mile point of Figure 1.)

By the use of these arrangements, carrier telephone systems may be applied to rural power distribution systems having maximum over-all lengths of from 10 to 20 miles, depending mainly on number of taps, ground resistivity (with which transmission loss varies directly), and type and size of line wire. Maximum over-all permissible line losses are about 40 decibels (including losses due to taps).

In addition to the line losses, the over-all loss from the common carrier terminal to the subscriber terminal is affected by various bridging losses and by the losses through the coupling units. Bridging losses are contributed by taps used for carrier transmission, by taps not used for carrier transmission which are equipped with tap chokes, and by distribution transformers on the power line. The bridging loss of taps isolated from the carrier path by tap chokes is ordinarily of the order of 0.1 to 0.2 decibel each. The bridging loss from a distribution transformer of 5 kva rating or smaller is also about 0.1 to 0.2 decibel. Larger transformers will probably introduce higher losses, and it may be found necessary to connect them to the power line through chokes.

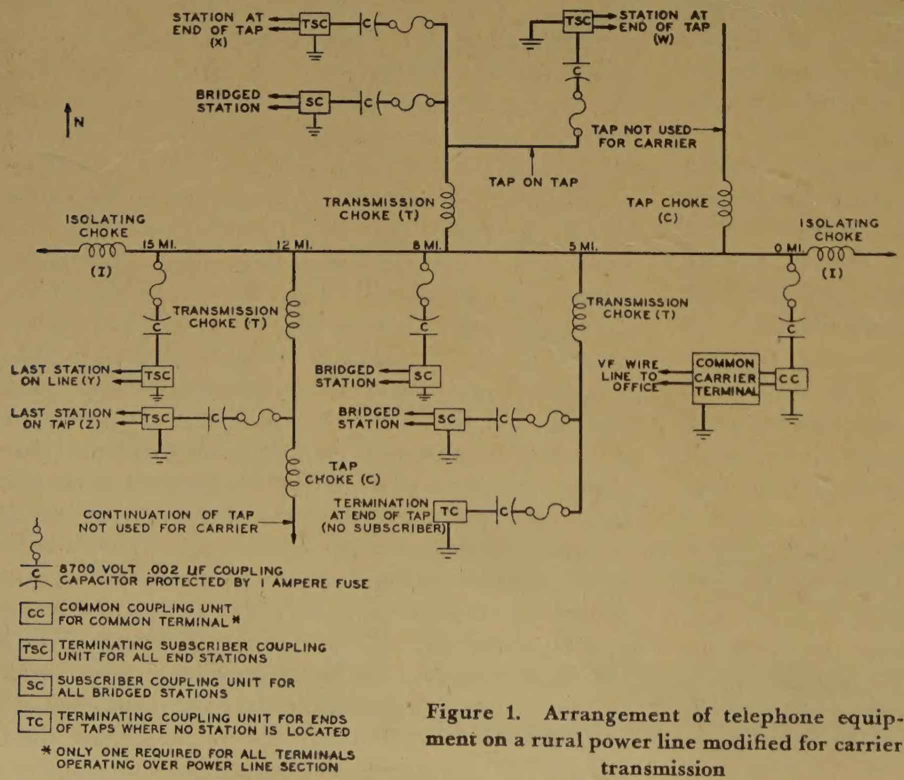

Figure 1. Arrangement of telephone equipment on a rural power line modified for carrier transmission

The reactance of the operating coil used in oil circuit reclosers may introduce a loss to carrier transmission of the order of 10 decibels. Preliminary information indicates that this loss may be reduced to about 0.5 decibel by shunting a noninductive 50-ohm resistance around the operating coil. Methods of mounting the resistance and its effect on the recloser's operation are being studied.

THE CARRIER EQUIPMENT

Figure 3 shows the principal elements of the *M1* carrier telephone system and illustrates their manner of use. Coupling capacitors and coupling units are used to provide coupling for subscriber stations, common carrier terminals, and terminating units.

Coupling Capacitor. The coupling capacitor (designed primarily for connecting the coupling units to the power lines) has a capacity of 2,000 micromicrofarads, and is rated at 8.66 kv. The impedance of the capacitor at 60 cycles is about 1,300,000 ohms, and consequently, the 60-cycle current is about 5 milliamperes. A fuse with a rating up to 3 amperes may be used in the connection between the capacitor and phase wire.

Coupling Units. Four different coupling units have been standardized for the *M1* carrier telephone system. Each coupling unit is housed in a galvanized iron coupling unit box as illustrated in Figure 2.

The coupling unit is connected in series between the capacitor and ground. The normal 60-cycle voltage drop across the coupling unit is less than 1 volt. Copper protector blocks with 0.01-inch separation break down at around 1,200 volts and thus protect the coupling unit for abnormal voltage conditions. A grounding switch is provided to ground solidly the capacitor lead when maintenance work in the coupling unit is required.

Subscriber Coupling Unit. This coupling unit is used for bridging subscribers and is designed so that it produces only a small bridging loss on the main line or tap to which it is connected. The installation is usually made on the primary pole nearest the telephone subscriber's premises with the coupling capacitor and a fuse. A telephone drop wire is run to the premises. In many instances this installation will be on the same pole as a distribution transformer, but it may be on a pole having only primary conductors.

Figure 4 shows a schematic diagram of the coupling unit circuit. *FL1* is a broad band filter passing all frequencies in the band 150–455 kc. *FL2* and *FL3* are narrower filters, *FL2* being capable of transmitting either of the two transmitting frequencies associated with the subscriber terminal and *FL3* tuned to pass the receiving frequency. The receiving filter is connected between *FL1* and the drop wire at all times, while the transmitting filter is connected only when relay *RL1* is operated, which occurs only when the subscriber is using his telephone.

Terminating Subscriber Coupling Unit. This coupling unit is similar to the subscriber coupling unit except that *FL1* has a different stepdown ratio and is terminated on the drop side in 100 ohms. This effectively terminates the line or tap to which it is connected in characteristic impedance at all frequencies during stand-by condition and at all but the particular subscriber transmitting frequencies when the telephone is in use. At the transmitting frequencies during the time that the telephone is in use, the line is terminated in about one half of its characteristic impedance and a small irregularity is caused thereby.

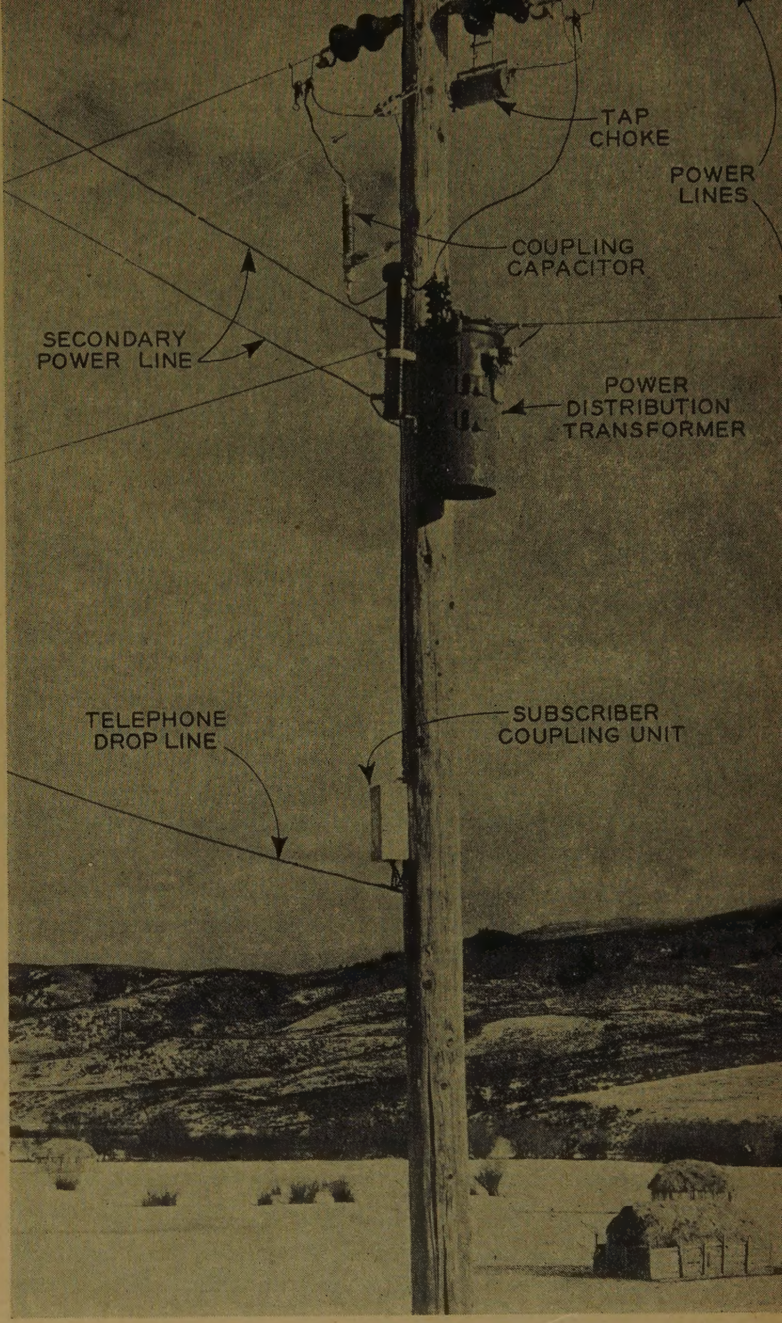

Figure 2. **A typical installation on the primary pole**

If no subscriber is located at the end of a power line section or tap, a terminating coupling unit is installed with a coupling capacitor. Except for the absence of the carrier drop the installation of this unit is similar to that for a subscriber station.

Common Carrier Terminal Coupler. The installation of the common coupling unit and its associated coupling capacitor is similar to the installation at the customer premises. The common coupling unit usually will be installed on the power pole nearest to the central office, and will be connected to the common carrier terminals over a short carrier drop.

This coupling unit, since it may be common to six channels, employs only the broad filter *FL1* used in the terminating subscriber coupling unit. The drop side of this filter is connected directly through drop wire to the common terminal by means of which the power

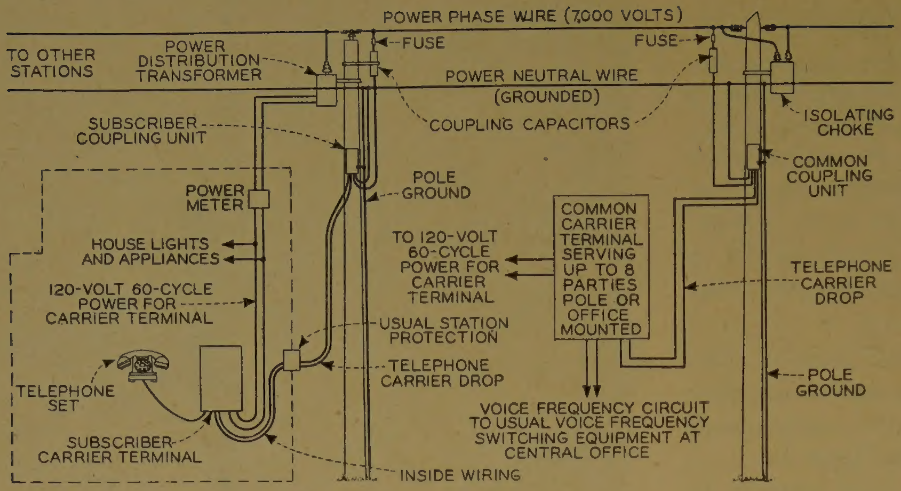
POWER PHASE WIRE (7,000 VOLTS)
TO OTHER STATIONS
POWER DISTRIBUTION TRANSFORMER
FUSE
FUSE
POWER NEUTRAL WIRE (GROUNDED)
COUPLING CAPACITORS
ISOLATING CHOKE
SUBSCRIBER COUPLING UNIT
COMMON COUPLING UNIT
POWER METER
POLE GROUND
COMMON CARRIER TERMINAL SERVING UP TO 8 PARTIES POLE OR OFFICE MOUNTED
HOUSE LIGHTS AND APPLIANCES
TO 120-VOLT 60-CYCLE POWER FOR CARRIER TERMINAL
TELEPHONE CARRIER DROP
120-VOLT 60-CYCLE POWER FOR CARRIER TERMINAL
USUAL STATION PROTECTION
TELEPHONE CARRIER DROP
POLE GROUND
TELEPHONE SET
VOICE FREQUENCY CIRCUIT TO USUAL VOICE FREQUENCY SWITCHING EQUIPMENT AT CENTRAL OFFICE
SUBSCRIBER CARRIER TERMINAL
INSIDE WIRING

Figure 3. Principal elements of the M1 carrier telephone system

line is effectively terminated in characteristic impedance at the frequencies assigned to the common terminal. Other common terminals up to the full complement of six may be connected to a single common coupling unit. If all six common terminals are so connected, the power line would be terminated at all frequencies of interest.

Terminating Coupling Unit. This coupling unit is identical with the common coupling unit except that 100 ohms is connected across the drop side of the common filter *FL1* thus terminating the power line in approximately characteristic impedance.

Common carrier terminals are usually located at one end of a carrier section and no separate means for terminating the power line is required as the common carrier terminal always provides approximate characteristic impedance at the carrier frequencies used.

Subscriber Terminal and Telephone Set. The subscriber carrier terminal is installed in the same manner as a conventional telephone wall box at a location close to a 60-cycle power outlet and the combined telephone set is conveniently located near the subscriber terminal. The installation of the carrier drop from the coupling unit to the subscriber's premises, and of the station protection and inside wiring to the subscriber terminal, is the same as for a voice-frequency rural station.

The block diagram shown in Figure 5 will serve to show the principles of operation of the subscriber terminal and telephone set.

The frequency of the transmitting oscillator is controlled by one or the other of two crystals corresponding to the two frequencies allotted for transmission purposes to a single subscriber terminal. The power amplifier consists of a single stage, operating class *A* with a maximum of two watts carrier output. Under stand-by conditions, no carrier is generated or transmitted due to the open filament circuit of the power tube and to the high positive bias applied to the heated filament of the oscillator modulator tube. The output filter is broad enough to pass either of the transmitting frequencies but narrow enough to prevent effectively unwanted harmonics from being transmitted.

The receiver employs two tubes and associated filters as indicated. Automatic gain control is provided which keeps the range of voice-frequency levels at the demodulated output within about three decibels for a range of input levels of 30 decibels, assuming a constant percentage modulation. A sensitive relay operates from the d-c component of the demodulated signal, and is directly associated with the ringer and frequency control circuits. The receiver is energized at all times to receive signals. Under stand-by condition, however, the potential applied to the screen of the second receiving tube is 60-cycle alternating potential derived from the 60-cycle power supply so that the receiver is able to receive signals only if the time of arrival of the signals coincides with the time of arrival of the positive potential from the 60-cycle power supply. This method of energization during stand-by periods provides for divided code ringing.

When the handset is lifted from the cradle to originate a call or to answer a ring, six functions are performed:

1. A connection is made which provides the telephone transmitter unit with normal current.

2. The oscillator modulator and power amplifying stages are completely energized. The frequency of the oscillator has been predetermined according to whether or not a sufficient magnitude of carrier energy at the receiving frequency was on the receiver input before the receiver was lifted. If no receiving carrier (or an insufficient amount of the receiving carrier) was on the receiver input, the normal frequency is generated. If a sufficient amount of receiving carrier was on the receiver input, the reverting frequency is generated.

3. The frequency control is disabled. If the preselected frequency was normal frequency it will remain normal frequency. If the preselected frequency was reverting frequency, it will remain reverting frequency as long as sufficient carrier at the receiver's frequency is present at the input to the terminal. If the receiving carrier disappears or is reduced below a receivable level, the transmitting frequency will return to normal and will remain normal even though a sufficient magnitude of receiving carrier later appears. These functions are performed by relays.

4. A few watts of a-c power are applied through the drop wire to the coupling unit to operate the relay in the transmitting circuit.

5. The potential applied to the screen of the second receiver tube is changed from alternating to positive direct potential.

6. The demodulated voice-frequency output of the carrier frequency receiver is connected through to the telephone receiver.

Under these conditions the terminal is arranged both to receive and transmit. In a manual area further signaling is accomplished verbally in the usual manner. In a dial area the subscriber operates his dial in the usual manner which alternately opens and closes the plate supply to the modulator section of the oscillator modulator tube. This causes carrier to be sent out during the closed periods of the dial contacts but to be cut off during the open periods of the contacts. This signal is received at the common terminal and produces alternate closures and opens in the d-c path associated with the voice-frequency loop, thus operating the central office dial equipment in the normal manner.

Common Terminal. If circumstances permit, it is desirable to install the common carrier terminals in the central office and to connect them to the common coupling unit over a short carrier drop. This arrangement facilitates installation and maintenance. In many cases, however, the power line over which carrier is to be transmitted will be some distance from the central office and it will be necessary to install the common terminals in an outdoor housing mounted near the base of a telephone or power pole. A voice-frequency pair between the central office and the common terminal location is required for each channel. The voice-frequency facilities may be the same as would be required to provide satisfactory transmission to a voice-frequency station with local battery transmitter supply and located at the same point as the common terminals. A single carrier drop is used to connect as many as six common terminals to the common coupling unit. Each common terminal is provided with a 120-volt 60-cycle power supply.

The important function characteristics of the common terminal may be described with the aid of the block diagram shown in Figure 6.

In the stand-by condition, both the reverting and normal frequency receivers are energized completely to receive signals. The filaments of the transmitter tubes are heated and plate power is applied, but the grids are negatively biased to such an extent that no carrier is transmitted. The transmitter can be made to put out carrier by either the ringing control circuit or by the normal receiver control circuit.

When ringing power is applied between either or both of the voice-frequency loop wires and ground, the ringing control operates to apply pulses of normal bias to the grids of the transmitter tubes. These pulses have a 30-cycle frequency and are synchronized with the 60-cycle supply used to supply power for the terminal. The particular phase of the 60-cycle power with which the pulses are synchronized depends on which of the two line relays associated with the ringing control is pulled up by the applied ringing power, that is, the relay connected between tip side of the line and ground, or the relay connected between the ring side of the line and ground. The pulses that are transmitted when the tip relay operates cause ringing at all subscriber terminals poled so as to be enabled on the phase of 60 cycles corresponding to the tip pulses, and similarly when the the ring relay operates, ringing is caused at all subscriber terminals correspondingly poled. If both tip and ring relays operate, ringing is caused at all subscriber terminals on the channel.

The limiter associated with the oscillator modulator stage of the transmitter operates by separating the voice-frequency output of the stage from the carrier output, rectifying it and applying the resulting direct current via the limiting circuit shown in the diagram to the hybrid coil where it is applied to biased varistors shunting a coil winding. When the d-c potential associated with the returned direct current is sufficient to overcome the bias on the varistors, the current passes

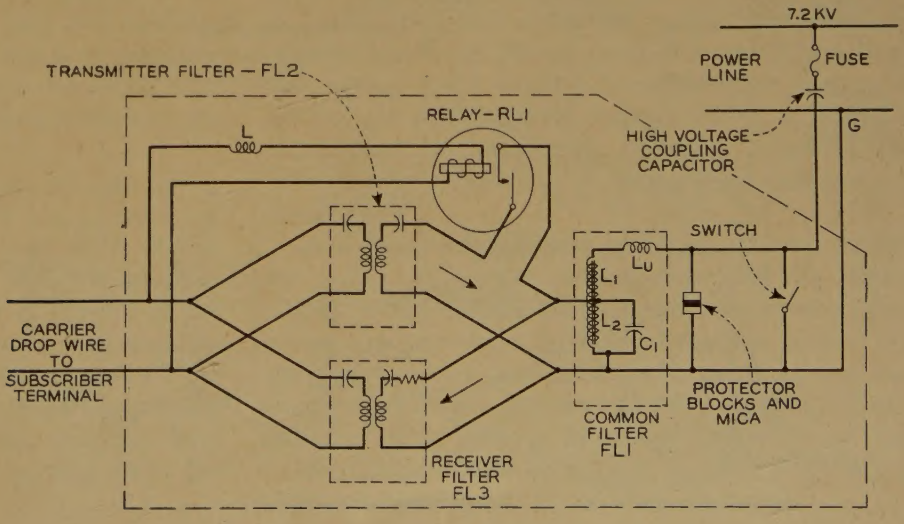

Figure 4. Schematic diagram of the subscriber coupling unit

through them in the forward direction reducing their resistances, shunting the coil and reducing the speech level transmitted to the oscillator modulator over the transmitting branch.

When an adequate amount of normal carrier receiver current is received at the terminal, the normal receiver control operates to disable ringing control and to establish normal grid bias on the transmitter tubes. The normal receiver control also transfers the voice-frequency loop to the pad and hybrid line circuit and makes the d-c closure giving the supervisory signal to the local office and setting up conditions for speech transmission or further signal transmission either verbally or by dialing.

When revertive frequency carrier is applied to the terminal, the revertive receiver control bridges the demodulator voice-frequency output across the receiving branch of the hybrid circuit and destroys part of the network balance in order to secure better transmission from the receiving to the transmitting branch of the hybrid on reverting calls.

DESIGN CONSIDERATIONS

The performance of the rural carrier telephone system may be affected by atmospheric static, noise due to power line sources, and by near-by radio stations or other carrier systems operating in the same frequency range. The effects of atmospheric static are dependent on the severity and duration of thunderstorms, on the earth resistivity in the vicinity of the power line, and also on the frequency at which the carrier channel is operated.

While the maximum noise on the carrier channels ordinarily will occur only during peak periods of atmospheric static, there may be cases where noise will occur from power line sources. These sources are the same as those that may create interference with radio reception such as punctured or cracked insulators or loose hardware and their location and elimination is handled in accordance with usual power system practices.

Signals from near-by radio stations or carrier systems operating in the same frequency range as the rural carrier telephone system in some cases may be a possible source of interference with telephone transmission. In engineering applications of the carrier system, it will be desirable to avoid using carrier channels which operate at the same frequencies as radio stations in the vicinity of the power line. The design of the carrier equipment which provides the possibility of associating any pair of transmitting frequencies with any receiving frequency facilitates the most effective use of the available frequency space which is free from external interference. The avoidance of the use of affected channels further will reduce the possibility of interference with radio stations through operation of the low powered carrier system.

As at present designed, only one 6-channel carrier system can be applied successfully to any single section of power line. However, it appears practicable to operate carrier channels at the same frequency on adjacent power line sections, provided suitable carrier frequency sectionalizing networks are inserted between the power line sections. The degree of effectiveness required of the sectionalizing networks will vary depending upon the cross talk requirements in each case. While the development work on these networks has not been completed, it is expected that they generally will consist of isolating chokes as series elements in combination with coupling capacitors as shunt elements.

Most of the applications of the rural power line carrier telephone system have been made on single-phase power lines with multigrounded neutrals. The results of tests conducted during the summer of 1946 indicate that in general it will be feasible to operate the carrier system over lines having two or three phase wires and multigrounded neutrals. Preliminary information indicates that phase-to-phase coupling for the common carrier terminal with phase-to-ground coupling of sub-

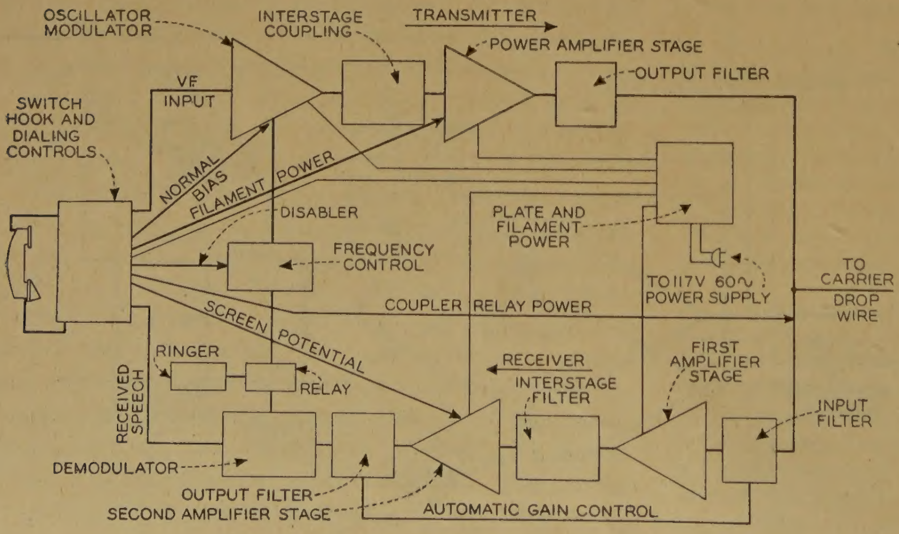

Figure 5. Block diagram of the subscriber terminal and telephone set

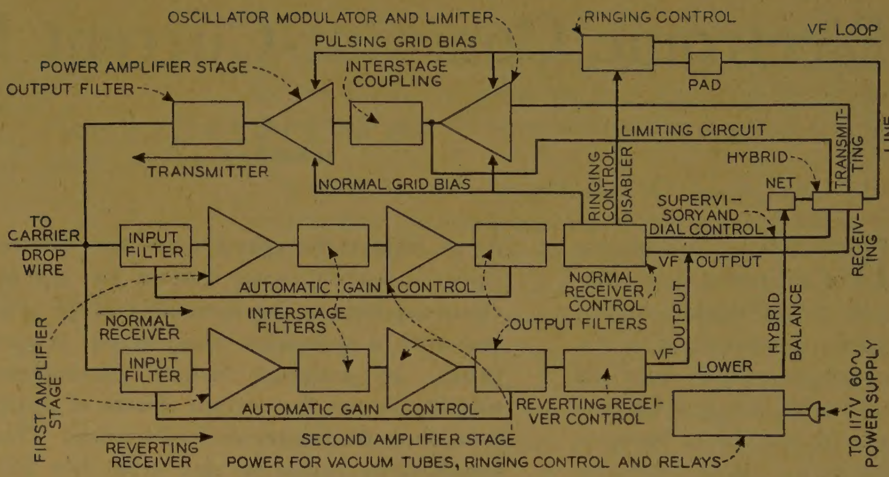

Figure 6. Block diagram of the common terminal unit

scriber stations may be feasible. The metallic circuit transmission characteristics are expected to be comparable with that obtained on the multiphase line with primary neutral.

MAINTENANCE CONSIDERATIONS

After the carrier telephone system is in operation, under usual conditions very little power line maintenance should be required other than that normally required in providing reliable power service. Power interruption to a telephone subscriber, of course, will cause an interruption to the subscriber's telephone service. Power interruption to a common carrier terminal will make inoperative all telephones on the carrier channel. When maintenance work is required, close co-operation is desirable between local maintenance forces of the power system and telephone company. This will include arrangements for clearing of troubles, replacements of capacitors, fuses, and chokes, advance notification of planned power system interruptions, and correction of power line conditions which create interference with carrier transmission.

APPLICATIONS TO TELEPHONE PAIRS

Although the rural carrier telephone system is designed primarily for use over power lines, it is expected that it also will be found useful as a means of providing additional circuits over rural open wire telephone lines. One such application already has been made and the results are satisfactory.

The same carrier equipment is used for both power line and telephone line service with the exception of the coupling capacitors and heavy duty series chokes. Low voltage capacitors associated with the coupling units are used to couple the carrier equipment to the telephone pair. Small carrier frequency chokes are used in series with the telephone pair to separate the carrier section from the purely voice-frequency portions of the circuit. Methods of connecting branches used for carrier service to the main lines are also under development.

Data available at present indicate that satisfactory transmission can be secured over copper or copper-steel metallic circuits with regular transpositions. The losses of steel pairs with light galvanizing are relatively high (up to 7 decibels per mile at 450 kc) and the use of substantial lengths of such conductors appears impracticable.

FIELD OF USE

The ultimate field of use of the power line carrier telephone system in comparison with other means of extending rural telephone service will depend on several factors, which can be accurately evaluated only after considerable experience with the carrier system has been obtained.

The afore-mentioned factors include the cost of the equipment for the carrier system, the arrangements which are worked out between the telephone and power organizations in connection with this type of service, the demand for rural telephone service in areas more remote from existing wire telephone facilities, and, probably most important, the operating and maintenance experience with the carrier system.

The results of preliminary studies of the probable field of use for the carrier system have indicated that it will be most attractive where the prospective telephone customers who are served by power distribution lines are remote from existing telephone pole lines. In general the carrier system appears worthy of study in cases where the prospective telephone customers are separated by distances of the order of one-half mile or more.

In deciding whether rural service should be extended by carrier or by wire, the relative flexibility of the carrier system deserves particular consideration. Telephone service can be furnished from any channel to customers located anywhere along the section of the power system which has been modified for carrier transmission. This permits maximum utilization of the carrier channels installed initially and facilitates adding additional customers.

Electronic Constant-Current Motor Systems

O. W. LIVINGSTON
MEMBER AIEE

As an adjustable speed drive the electronic constant-current motor system has the same characteristics as the variable voltage system but with a minimum complement of power tubes. Its constant torque characteristics simplify its use for certain classes of application, such as maintenance of tension. These installations range in size from 1/4 horsepower to $7^1/_2$ horsepower and have a definite advantage in use with electronic control.

BEFORE the development of electronic tube control the adjustable voltage system, consisting of a d-c motor energized from an adjustable voltage d-c generator driven by a separate d-c or a-c motor, was considered generally to be one of the most flexible drives for adjustable speed applications.

The most commonly employed adjustable voltage system is basically an adjustable voltage d-c supply for a shunt-wound d-c motor. At any fixed direct voltage it is basically a constant speed drive, capable of supplying either positive or negative torque with only a slight speed change. When positive torque is supplied power flows from the motor-generator set to the drive motor. If the load has an overhauling characteristic the motor speed increases only slightly to permit its voltage to exceed that supplied by the motor-generator set, and the current and power flow are reversed.

If the armature of a d-c shunt-wound drive motor is supplied from a controlled rectifier its speed may be controlled in a manner similar to the variable voltage system as long as power is being supplied to the motor. However, if the load of the drive motor becomes overhauling, it is not possible to reverse the current in the d-c circuit to provide negative torque, because a simple rectifier basically permits current flow in only one direction. Although it is possible and practical in some instances to supply the drive motor from two paralleled reversely connected controlled rectifiers, this increases the size of the power unit and the complexity of the control. An electronic constant-current control system was developed which overcomes many of the disadvantages cited.

BASIC CONSTANT-CURRENT PRINCIPLE

In this system, the armature of a standard d-c shunt motor is excited from a constant-current source which is a phase-controlled rectifier and regulator that adjusts the output voltage to the value necessary (within the designed voltage limits) to maintain the average d-c current constant. The field of the motor is supplied by a pair of reversely connected controlled rectifiers in order that any desired positive or negative value may be attained. These reversely connected rectifiers, because of smaller power requirements of the field, do not present quite the same problem that their use in the armature did.

This system is inherently an adjustable constant-torque system. If the field flux is set at zero, zero motor torque will be developed; if the field flux is made either positive or negative a positive or negative motor torque will be developed, which, if the motor were connected to a rising torque characteristic load such as a fan, would cause positive or negative rotation at increasing speed until the load torque equaled the constant torque developed by the motor. The constant-current armature rectifier automatically will adjust its voltage as the counter electromotive force of the motor builds up so that the current flow remains constant. At zero speed the output voltage is very low, just enough to supply the *IR* and brush drop. The rectifier voltage increases proportionally with the motor speed increase. Because negative rotation is accomplished by reversing the field, the counter electromotive force always has the same polarity and the rectifier voltage is positive, indicating positive power for motoring in either direction.

However, if the drive motor is excited to give positive torque and the machine is rotated mechanically in the negative direction by an external driving device the counter electromotive force of the machine will be reversed and will be in the direction to increase the armature current flow. In order to keep the armature current constant it is necessary that the output voltage of the rectifier go to a negative value or act as an inverter.

Figure 1 shows this relation for a particular value of armature and field current which produces a fixed torque.

There is no fundamental difference between a controlled rectifier and an inverter. If a controlled rectifier is supplying a load which has sufficient inductance to maintain the direct current continuous and is able to reverse its voltage (that is, able to become a generator rather than an absorber of power), the average output voltage of the rectifier may become negative after the phase of the grid is retarded beyond the 90-degree lagging point.

Essentially full text of paper 47-69, "Electronic Constant-Current Motor Systems," presented at the AIEE winter meeting, New York, N. Y., January 27–31, 1947, and scheduled for publication in AIEE *TRANSACTIONS*, volume 66, 1947.

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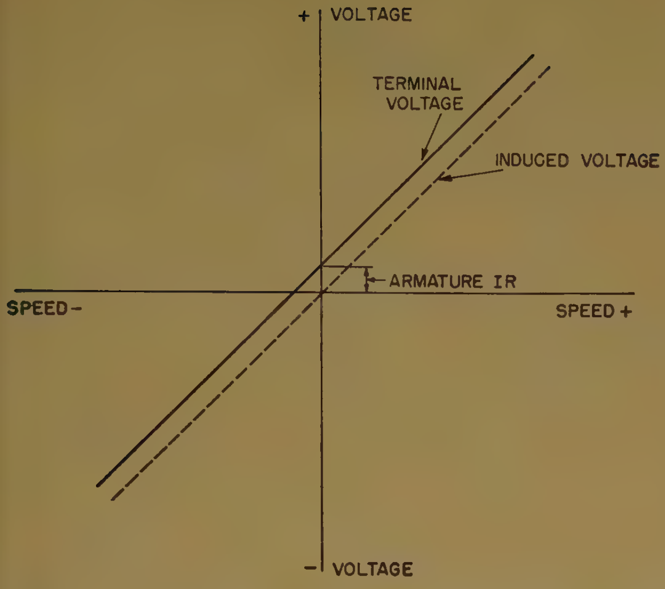

Figure 1. Relation between armature voltage and motor speed, operating at constant armature and field current

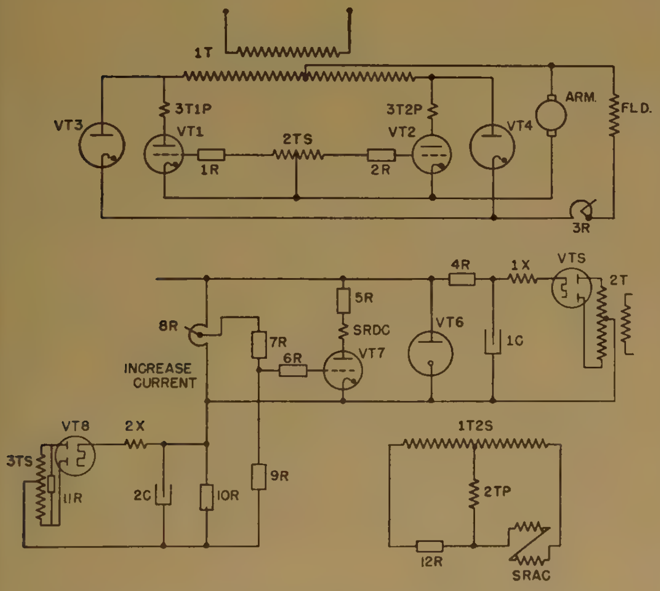

Figure 2. Simple constant-torque motor control

Although insufficient inductance in the armature circuit may cause the current to become discontinuous, it is still possible to invert and pump back when the counter electromotive force of the motor reverses.

CONSTANT TORQUE CIRCUIT

Figure 2 shows an elementary diagram of a simple constant-torque motor control. The anode transformer together with the armature tubes, VT_1 and VT_2, and the field tubes, VT_3 and VT_4, supply the armature and field, respectively, of a d-c motor. The field rectifier is shown uncontrolled and the field current varied by the rheostat *3R*. If both positive and negative torques were desired, a field reversing contactor or switch could be added.

The grid control of the armature rectifier is affected by the grid transformer *2T* which in turn is energized by the simple *R-L* phase-splitting circuit involving the resistor *12R* and the a-c winding of the saturable reactor *SRAC*.

A special current transformer *3T* having two primaries, one in series with each of the armature tubes, is used to obtain a current signal. The secondary of the transformer is shunted by a resistor *11R*, and the secondary voltage is rectified by the tube *VT8*. The output of this rectifier then is filtered and used to affect control of the tube *VT7*. It will be seen that the grid voltage of tube *VT7* is the result of two signals, the positive "turn on" voltage from the potentiometer *8R*, and the negative "turn off" voltage from the armature-current signal rectifier. The magnitude of these two voltages and the relative value of their feed resistors *7R* and *9R* determine the grid voltage of *VT7*. Under steady operating conditions an equilibrium is reached in which the current through the tube *VT7* is sufficient to produce the phase shift which produces the required output voltage which in turn causes the required armature current to flow and produces the correct armature current rectifier output voltage to maintain the grid voltage at the required value. However, if the armature current decreases, because of a change in the motor load, the negative current signal voltage would decrease and the grid of *VT7* would become more positive. This would result in more anode current through *VT7*, increased saturation in the saturable reactor, a phase advance in the grid excitation, greater rectifier output voltage, which finally would cause the armature current to increase until it attained substantially its former value. Similarly an increase in armature current would have the reverse action of these components with the result that the current would be reduced to essentially its initial value.

This is a very simple armature current regulator which can be adjusted to any desired value of armature current by means of the potentiometer *8R*. This control then gives the motor a constant torque characteristic which may be set to any value by adjusting either the field strength and/or the armature current. Figure *3A* shows the idealized speed-torque characteristics possible by different per-unit armature currents with full field. Once the torque setting is made, the motor will develop this torque regardless of the direction of rotation within the motor rating. The dotted line at top and bottom of the curves represents rated armature voltage which occurs at full basic speed if full field excitation has been maintained. In Figure *3B* are plotted the family of curves resulting from regulating the armature current at one fixed value and adjusting the field for definite values of either positive or negative flux. The per-unit armature voltages at the various operating points are indicated by the dotted lines. Note that the voltages which are proportional to input power at constant armature current are positive in the first and third quadrants, which are the normal motoring quadrants, and negative in the second and fourth quadrants, the generating quadrants. It is seen that if reduced torque is obtained by field weakening it is possible to run the machine above basic speed provided that the load torque is reduced correspondingly without exceeding rated armature voltage. This is similar to the constant horsepower obtained in the field weakening range in the more familiar constant-voltage operation.

CONSTANT SPEED CONTROL

Figure 4 is the diagram of the main power circuits of a simple constant-current motor speed control consisting of a controlled rectifier supplying the armature and a pair of reversely connected controlled rectifiers supplying the field. As in the previous circuit current transformers in the anode of the armature tubes in co-operation with a rectifier and filter provide a d-c control voltage proportional to armature current.

Figure 5 shows the control circuit used to control the power circuit of Figure 4 to obtain speed control. To obtain speed control a d-c tachometer mounted on the motor shaft is compared with the d-c speed signal determined by the setting of the potentiometer *R22,* and the difference or error being fed to the grid circuit of the amplifier tube *VT9.* The tubes *VT9* and *VT10* have a large common cathode resistance and operate basically as a type of phase inverter sometimes called a "long tailed pair." The output of these two tubes, which move in opposite directions as the input to the grid of *VT9* is changed, are coupled by means of potentiometers to the saturable reactor tubes *VT11* and *VT12* which, through their respective saturable-reactor phase-shift circuits, control the negative and positive field rectifiers.

In the case of zero speed equilibrium conditions, the potentiometer *R22* is in midposition so that the voltage of the slider to the middle voltage bus is zero. The output of the tachometer is zero. Thus the grid potential of the tube *VT9* is the same as that of *VT10.* Because their inputs are balanced, the output voltages are the same and the saturable reactor tubes each are passing a very small but equal current with the result that there is zero-field voltage and current. Under this condition the motor stands still even though the preset armature current is flowing, because if there is no field there can be no torque.

If the speed control potentiometer is turned now to give positive voltage with respect to the middle bus, the equilibrium is destroyed. As the grid of tube *VT9* is made more positive by this action its anode current increases and its anode potential decreases. Because of the coupling in the common cathode or "tail" the anode current of *VT10* decreases and its anode potential increases. This action decreases the small current in the negative saturable reactor tube *VT11* to zero and increases the current in the positive saturable reactor tube.

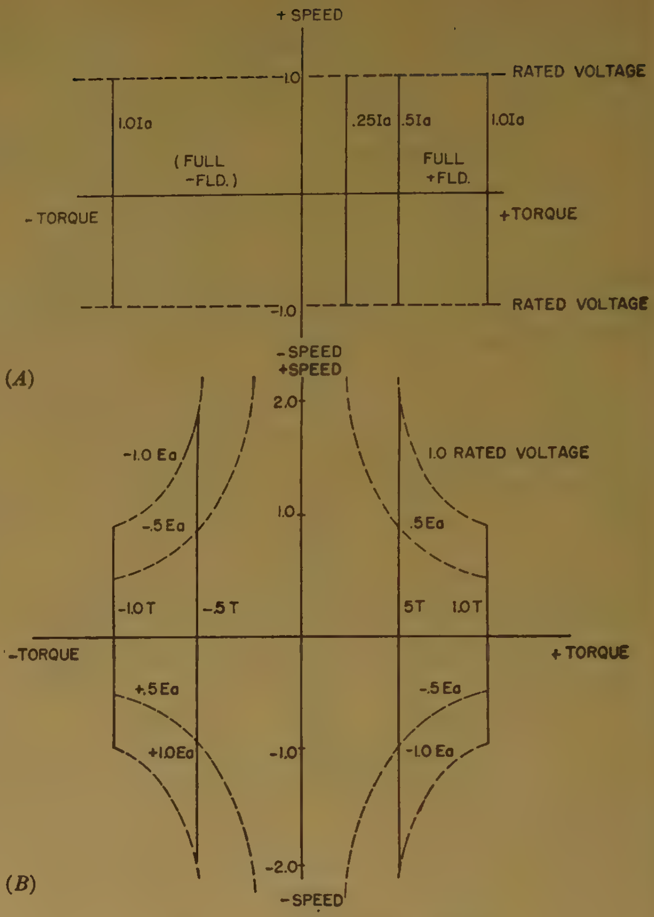

Figure 3. Speed-torque relations

A—With full field and several armature currents
B—With full armature current and several different field currents

This causes the negative field rectifier to be turned completely off and the positive field rectifier to be turned on, and in turn produces positive field current, positive torque, and motor rotation in the positive direction. As the motor speed increases the tachometer voltage rises, tending to counteract the positive voltage of the speed signal supplied by the potentiometer *R22.* Finally, another new equilibrum is reached in which the tachometer voltage has increased sufficiently to bring the grid of tube *VT9* almost back to its initial condition. It generally must be slightly higher than formerly in order that sufficient net positive field still remain on the motor to produce the necessary torque to maintain that speed. If the load torque is increased now the motor speed decreases by only a small amount to permit the grid voltage of *VT9* to rise slightly so that the necessary increase in positive field and torque may be supplied. Because only a small change in grid voltage of *VT9* is necessary to obtain large changes in field it will be seen that such a device will give good speed regulation as the load torque is increased.

If the load torque were decreased and finally made negative, the speed would start to rise. However, as soon as the tachometer had risen a short distance the field excitation first would be reduced to zero and then reversed, giving rise to a negative torque which would be increased until it was equal to the overhauling torque of the load. Under this condition the induced voltage in the motor would reverse, but the power flow would have reversed and the armature controlled rectifier actually would be operating in the normal inverter quadrant. Thus it is possible to maintain substantially constant speed from full positive to full negative torque.

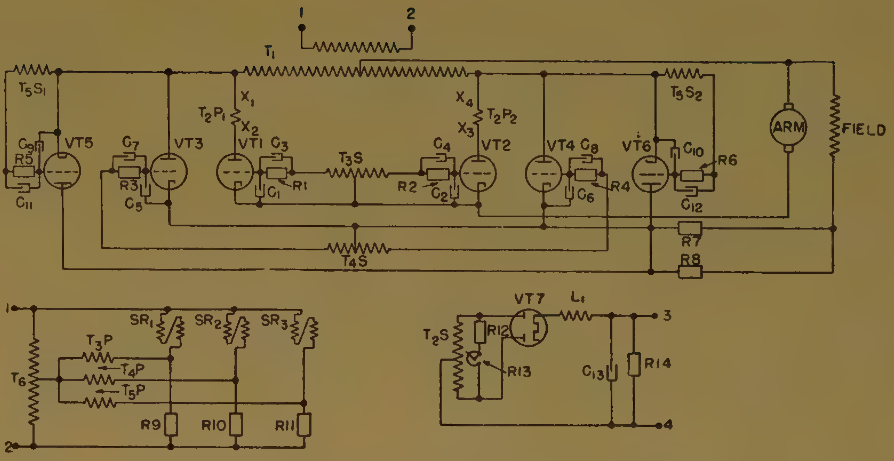

Figure 4. Main power circuits of a simple constant-current motor speed control

If the speed control potentiometer is moved suddenly to a lower positive speed the field excitation will reverse temporarily to apply negative torque, which is in effect regenerative braking until the machine has reached the lower speed at which time the positive field will be reestablished at a value required to satisfy the load torque at this speed. If the speed control potentiometer is turned so as to give a negative voltage the system regulates at a negative speed or the motor reverses. In this case the tachometer voltage reverses but the sense of all the voltages is such that no switching is necessary. When running in the negative direction with a power absorbing load, negative torque must be exerted or there must be a net negative field. A negative rotation and negative field result in a normal positive counter electromotive force on the motor. Any change in the nature of the load, tending to increase the speed in the negative direction, will result in the field excitation changing from negative to positive, reversing the induced voltage in the motor, and the constant-current rectifier again becomes an inverter to absorb the necessary power to maintain the speed.

This equipment is a very simple reversible motor control capable of responding to a speed-voltage signal of relatively small power and capable of either supplying or absorbing power to maintain the desired speed. This system has many desirable characteristics but has several disadvantages which lead to the modification described in the next section.

MODIFIED CONSTANT-CURRENT SYSTEM

Several disadvantages of the previous system will be evident. First, if it is necessary to obtain full output from the machine it will be necessary to set the constant-current control at rated current. This means that there will be full-load armature copper loss whether the machine runs at full load or at fractional load, at full speed or at zero speed.

Second, if sudden overloads of torque are thrown on the machine or are desirable for quick acceleration they cannot be met, because the armature current is set definitely at rated value. As the inherent characteristics of a motor are such that overcurrents of short duration within the limits of satisfactory commutation generally may be tolerated on a duty cycle basis, this simple constant-current system does not realize to the fullest degree the capabilities of the motor.

To overcome these objections the circuit shown in Figure 6 was developed in which there are two additional triodes known as "forcing" triodes with their anode circuits in parallel with the original constant-current regulator tubes. The grids of these tubes are excited through suitable potentiometers from the anodes of the original "long tailed pair" in the speed regulation circuits and are so biased that with that circuit at or near balance they are cut off. Under that condition the original constant-current tube has full control of the armature circuit rectifier and maintains constant current. However, this current may be set now at a low value such as one-half or one-quarter rated current so that the heating effect will be greatly reduced. If the load applied to this system is low so that the required torque may be produced with the reduced current, the system will operate substantially as a constant current system. However, as more torque is demanded by the load the field excitation is increased until full field has been reached. If the torque increases beyond this point the motor speed will start to decrease further causing still more unbalance of the output of the "long tailed pair" producing a grid voltage change on the grids of the armature forcing tubes. If the motor torque is insufficient and the unbalance becomes greater, one of these tubes starts passing current which increases the armature current sufficiently to produce the required torque. Thus after maximum field is reached in either the positive or negative direction, either the positive or negative armature current forcing tube increases the armature current to whatever value required even if several times normal. In order to limit this current under forcing conditions to a value which is safe for the motor commutation it is necessary to add an absolute current limit "take over" circuit including the two diodes with their respective anodes connected to the grids of the two "forcing" tubes. As long as the current signal is sufficiently small, the potential of the cathode of the "take over" diodes will be well above the middle supply bus so that their anodes, which are connected to the grids of the forcing tubes, will be negative with respect to their cathodes. Because no appreciable reverse current may flow, the current limit circuit essentially is disconnected. However, if the armature current continues to increase, the diode cathodes continue to fall, until finally the cathode becomes more negative than one of the forcing tube grids. This results in a current from anode to cathode and, because the diode has relatively low impedance in this direction and the current limit network is relatively "stiff" compared to the potentiometer supplying the forcing tube, the grid of the forcing tube is pulled negative and tends to regulate at this maximum current limit.

This system of operation can be modified by reducing the initial constant current to as low a value as desired, even to zero. In such an arrangement the constant-current regulator tube actually may be omitted and all armature current is the result of operation of the "forcing tubes" after full position or negative field has been called for.

OPERATION OF SPEED CONTROL SYSTEMS ABOVE BASIC

In some cases if acceleration is very slow, as when a slow-speed motor-operated speed control is used, it may be possible to run above basic, but if the speed control should be turned quickly the desired speed will not be attained. This may be explained in the following way in the simple constant-current system.

Assume that the speed potentiometer suddenly is turned to three times basic speed with the motor at standstill. Almost immediately a full positive field is obtained, and the motor starts to accelerate. At base speed the armature voltage reaches the full rating of the machine. If the rectifier has the ability to go to higher voltage it may continue to rise in speed; however, if it must go to three times basic, it would mean that both the armature voltage and the rectifier would have to go to three times rated voltage. After reaching the required speed the field would be reduced because only load torque must be developed, and if the load were within the rating of the motor the armature voltage would drop to within the rating. However, even if the motor could stand the overvoltage it would require a rectifier of three times the voltage rating just to take care of the acceleration. If the rectifier did not have this voltage capacity the rectifier voltage would rise with the armature until it reached its ceiling. The motor then would operate as a simple constant potential motor with full field and an armature voltage equal to the maximum rectifier voltage, far under the speed desired.

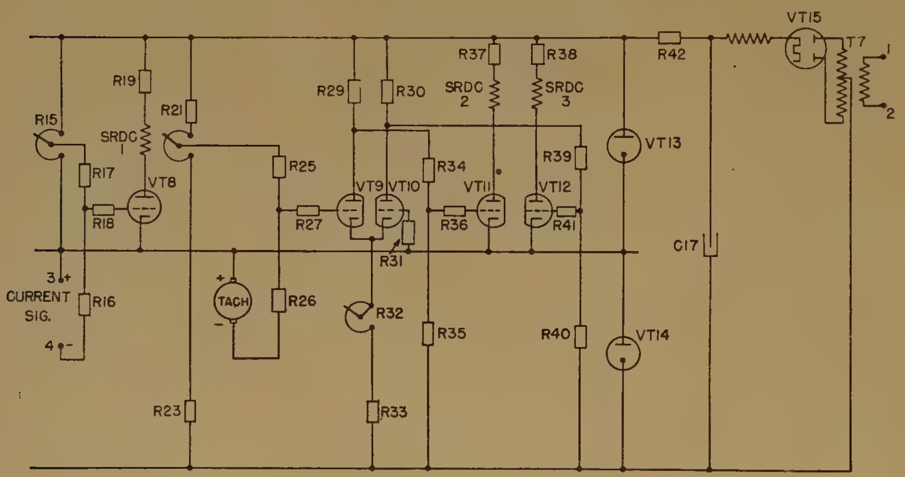

Figure 5. Control circuit for constant-current reversible speed control

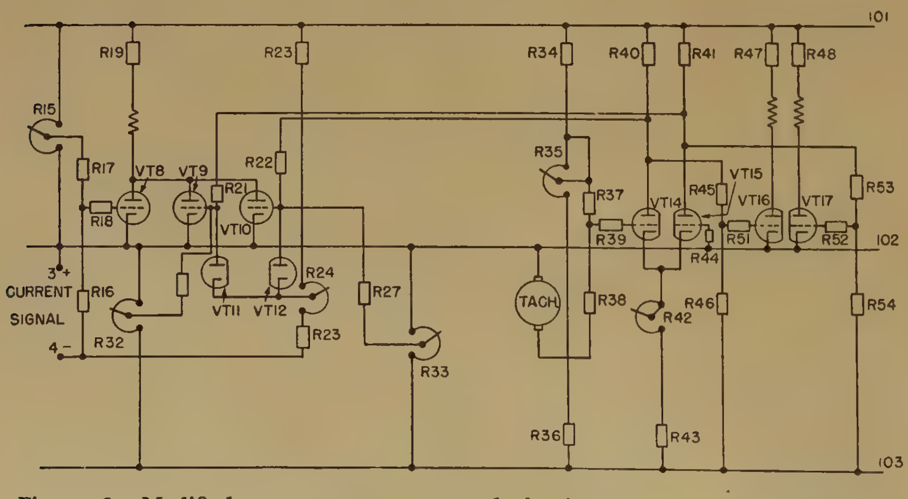

Figure 6. Modified constant-current control circuit employing armature forcing

In order to overcome this difficulty it is necessary to reduce the field excitation. This is possible if a field current "take over" is incorporated which weakens the field whenever the armature voltage gets too high, regulating the armature voltage at some reasonable value such as 110 per cent.

The torque is reduced, but if the load is within the machine rating at three times basic speed it must not exceed one-third basic torque so the motor will accelerate successfully to any operating point within its rating.

Although a number of different methods may be used to accomplish this, a simple field "take over" system is employed, using a magnetron and two "take over" diodes operating on the positive and negative field saturable reactor tubes in such a manner that the armature voltage may be limited to any desired value. As long as the armature voltage is below the desired value the magnetron passes sufficient current. As the voltage increases the magnetic field traversing the magnetron increases and its current decreases tending to regulate either the positive or the negative field at a value which just permits the desired armature voltage either positive or negative to be maintained.

A general system of constant-current and modified constant-current motor control has been described which has certain definite advantages for use with electronic control. A simple constant-current system has inherent constant torque characteristics which simplify its use in certain classes of application such as maintenance of tension. As an adjustable speed drive it has the same characteristics of the variable voltage system with a minimum complement of power tubes. Many other circuits and systems based on these fundamental methods have been devised which would be beyond the scope of this article. At the present time the author is aware of about 50 or 60 installations of this general type in operation or about to go into operation ranging in size from about 1/4 horsepower to $7^{1}/_{2}$ horsepower. It may be possible in the future to present more complete data on particular applications covering such points as speed of response, stability, economics, and operating experience.

The *XY* Dial Telephone System

H. R. REED
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Equipment for the *XY* switch, employed in a step-by-step dial telephone system, is light in weight and requires little floor space. Its package-type unit allows for exchange growth and standardization. Greater convenience in locating the called contacts as well as simplicity of circuits are offered. Only those switches required to accomodate the traffic need be mounted at the time of installation, with additional ones added as the traffic increases.

THERE are three fundamentally different methods of dial telephone switching in use today, the step-by-step, the power-driven, and the all-relay. The step-by-step method utilizes switches which are driven by magnets individual to each switch and controlled directly by dial pulses sent from the calling subscriber's station. The power-driven system has much common equipment upon which the operation of all the switches depend, in addition, of course, to the office power plant. These switches are not controlled directly by the dial pulses sent from the calling station. In the all-relay system there are no switches in the ordinarily accepted meaning of that term, because the so-called switching operations are performed entirely by relays or relay-type selecting units. In each system switches, or their equivalents in relays, are used for connecting a calling subscriber's line with link circuits and to switches which, in turn, connect those link circuits with the called subscriber's line.

Step-by-step dial telephone systems consist of subscribers' dial telephones together with central office switching equipment. The *XY* switching equipment consists of a line-finder, common to a group of subscribers' lines, together with associated first and succeeding selectors and connectors. After an idle line-finder has operated to find the calling subscriber's line and thereby connect him through to an associated idle first selector, dial tone is received, and the subscriber dials the desired number. The line-finder is referred to as a nonnumerical switch in that it performs the operation of locating the subscriber's line without the subscriber's operating his dial. This switch is started by the removal of the handset of the telephone at the calling subscriber's station, and the wipers, or brushes, are moved to connect to the calling line without that subscriber's intervention.

Essential substance of paper 47-76, "The Stromberg-Carlson *XY* Dial Telephone System," presented at the AIEE winter meeting, New York, N. Y., January 27–31, 1947, and scheduled for publication in AIEE *TRANSACTIONS*, volume 66, 1947.

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Most step-by-step systems are arranged on a decimal basis in that subscribers' lines or trunks are divided into groups of ten (or multiples of ten) units. In the *XY* system, the bank contacts are arranged in ten levels of ten contacts each, because this method offers the greatest convenience in locating the called contacts together with inherent simplicity of circuits.

When the subscriber dials, the first digit dialed sets the wipers of the first selector opposite the level corresponding to the digit dialed, whereupon a hunting action takes place to select a trunk to an idle second selector, or to the next switching unit in the switch train. The second digit is dialed and the wipers of the second selector are set opposite the level corresponding to the digit dialed, and a hunting action again takes place in exactly the same manner as in the case of the first selector. The procedure is repeated until all of the selections are made excepting that to the individual called subscriber's line and his particular ringing frequency or code, if he is one of several subscribers on a party line. If the called party is on a 1-party line, the two remaining digits of his number are dialed, and the wipers of the connector switch are set, successively, opposite the level corresponding to the tens digit of the called line and then on the contacts corresponding to the units digit of the called line, whereupon ringing of the called line takes place. If the called party is one of several persons on a multiparty line, a final frequency or code-selecting digit is dialed by the calling subscriber, and an additional selector switch is operated to select the desired means of ringing the bell at the called station.

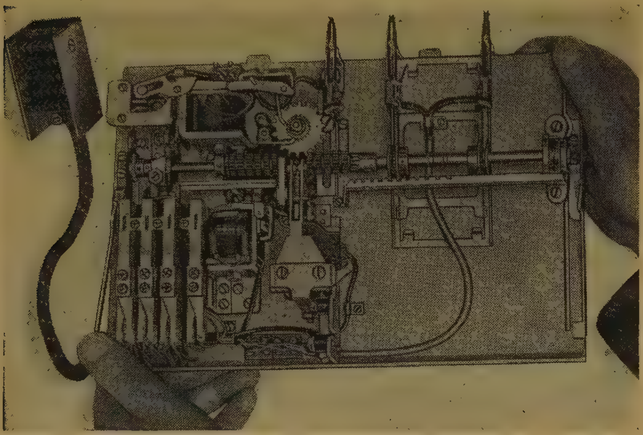

Figure 1. The *XY* switch

From the foregoing it can be seen that each rank selection is sufficient unto itself; that is, the subscriber dials a digit and the entire ensuing operation is performed completely within the switching circuit in question. A series of relays, associated with that switch, operate and in turn transmit the impulses received from the calling subscriber's dial to the stepping magnets of the switch which, in turn, set the wipers opposite the level corresponding to the digit dialed. In the connector, similar operations take place except that, unlike the rank selection switches, the wipers of the connector are set both opposite the level and on the particular contact dialed, completely under the control of the calling subscriber's dial, there being no hunting action over the contacts of the level selected. The line-finder performs neither a level-selecting operation nor a contact-selecting operation under the control of the calling subscriber's dial; hence, it is a nonnumerical switch.

THE *XY* SWITCH

The *XY* switch, Figure 1, is a flat type of switch and obtains its name by virtue of the fact that the wipers, during the movement to a desired position, traverse first in a direction to the right of the observer and then away from him which, in the right-hand rectangular co-ordinate system, are *X* and *Y* directions, respectively.

A carriage, which takes the two motions, has two pairs of wipers mounted on it for tip, ring, sleeve, and hunt connections. These wipers are bifurcated, employing twin contacts that make connection directly with bare wires which run in banks behind the switches. The bare wires are arranged in molded frames which are mounted rigidly to cells that, in turn, hold the switches. This group of bare wires, or multiple, will accommodate up to 50 switches with only one set of soldered connections.

The switches are mounted in die-cast aluminum cells, each cell capable of mounting two switches, and are connected to their associated relays by means of plugs and jacks. Because of the ease with which switches can be added to a unit, only those switches which are required to accommodate current traffic need be mounted at the time of the installation and additional ones added as traffic conditions increase.

Because the *XY* switch is a 100-point switch, the *X* motion is given ten steps (plus one which provides for marking overtravel) and the *Y* motion ten steps, thereby making possible the selection by the wipers of any one of 100 lines. An 11th step in the *Y* direction again marks overtravel. Because four wipers are involved, and each wiper has its own set of 11 wires, 44 rows of wires each 11 deep are lined up along the front edge of the mechanism plate immediately before the wipers to form the multiple.

To mark the level of *X* travel for finder operation, timing, or discriminatory purposes, another wiper enters a separate or 23rd wire bank. See Figure 2.

Four sets of control springs are used in the *XY* switch: *X* off-normal, *Y* off-normal, overflow, and release. The *X* and *Y* off-normal springs perform similar functions, that of informing the relay equipment associated with each switch as to the position of the brushes or wipers. Operation of the *X* off-normals, for instance, indicates that the switch has taken at least a single step in the *X* direction. Operation of the *Y* off-normals similarly indicates that at least a single step has been taken in the *Y* direction. In the event of certain incorrect dial manipulations or an all-trunks-busy condition, hunting switches may progress the entire length of the bank without encountering a stopping signal. Unless some means of correction were provided, they would continue to hunt vainly until the circuit was de-energized. Overflow springs, arranged to operate in the extreme position of the wipers in either the *X* or *Y* directions (namely, the 11th *X* or *Y* step), interrupt the magnet current in order to stop instantly and permanently useless stepping until the switch is released.

The release springs have two important functions in connection with the release of the switch. First, it is necessary to continue the release signal until the switch is fully home despite any immediate re-energization of the circuit which might occur. Second, there must be positive protection against premature seizure of a switch before it is fully home.

All *XY* switches are identical whether they be used as line-finders, selectors, or connectors. The variations in functional operation are obtained by virtue of the relays to which a switch is connected and not by the switch itself.

XY EQUIPMENT

The *XY* switches, together with their control relay sets' are mounted on frames to form bays. These frames assume various sizes and shapes depending upon the equipment to be mounted on them.

In general, bays are of four distinct types. These are

1. Originating or finder-selector bays which mount the *XY* switches (with associated relays) that find the calling subscriber's line as well as the switches that make the first selections in the call.

2. Intermediate bays which mount the various stages of selectors, other than the first.

3. Terminating or connector bays which mount the switches used to connect to the desired parties.

4. Miscellaneous bays used for various purposes such as cross-connecting and grading of selector multiples, mounting of interoffice trunk circuits, power charge and discharge units, and wire chief test facilities.

The relay mounting strips contain one, two, or three rows of relays, capacitors, and associated apparatus. The 2-row strip occupies the equivalent space of two single rows or the height of the 2-switch cell, while the 3-row strip is equivalent to three single rows. On the rear of the strip are mounted the appropriate number of multiple-point plugs to fit into jacks to which the frame cabling is attached permanently, and on the front is mounted a multiple-point jack to which the *XY* switch plug attaches. The relays are protected on the back by the bay framework and other relays and on the front by removable formed covers.

The originating bay mounts the regular terminal blocks for incoming cables, the fuse panel for power distribution within the bay, and the following switching circuits for handling the originating or calling end of a maximum of 100 subscriber lines. On the front of the bay are 20 line-finders arranged in two groups of ten line-finders each, one dual allotter consisting of two circuit units each of which is associated with one of the two line-finder groups, and 20 first selector circuits, also in two groups of 10 selectors each, these being tied to their respective line-finders. This bay has then a capacity of 20 links or finder-selector combinations to give a possibility of 20 simultaneous outgoing connections from the particular 100-line group.

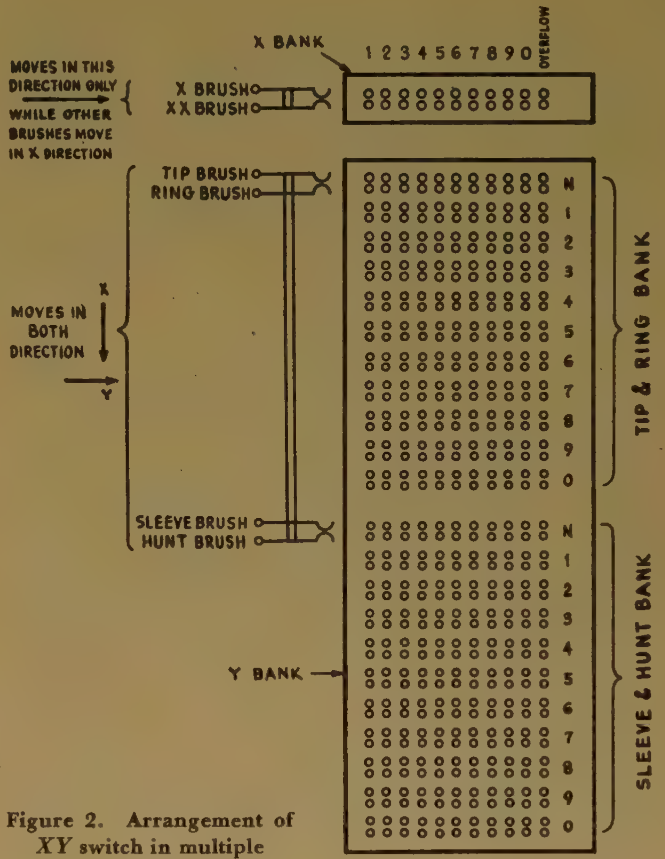

Figure 2. Arrangement of *XY* switch in multiple

On the rear of this bay are mounted the 100 line circuits. There is also capacity on the back of the bay for a total of three reverting call circuits, used to complete calls between two parties on the same line, one busy verification selector, and one common timing and alarm circuit.

Because all of the foregoing equipment with the single exception of the dual allotter is jack-mounted, it is very easy to cater to traffic changes and to exchange growth or reduction. The traffic of an original installation, for instance, may be such as to justify only 14 links per 100 lines, in which event only the first 14 line-finders (and of course their respective first selectors) need be equipped, the unequipped positions being covered with simple blanks. Sudden changes in traffic may require the addition or removal of several of these links to continue economical or satisfactory operation. This is accomplished by simply jacking in or out the required number of line-finder-selector combinations. In the same manner, a partially equipped bay (from a line standpoint) may be added to at any time by merely jacking in new line-relay strips made in units of 10 lines each.

The intermediate, or selector, bays are of two basic types, single-sided and double-sided. The single-sided bay uses the same framework as the originating bay, whereas the double-sided bay, using a similar iron framework, is arranged to mount units on both front and rear. *XY* switches, together with their respective circuit plates, can be mounted on both front and rear of these bays, because there is no individual line equipment to be mounted as in the case of the originating bays.

Terminating bays are similar to intermediate bays in that they also are made up in two types, single-sided and double-sided.

CIRCUIT FEATURES

The line circuits are jack-mounted in strips of ten and may be of the 2- or 3-relay types, the latter providing lock-out service. Both types are mounted on interchangeable mounting plates which permit the percentage of lockout-type lines in an originating bay to be changed at will from 10 per cent to 100 per cent in multiples of 10 per cent. This is an especially valuable feature in small community dial offices where the number of rural lines (normally provided with lockout service) may decrease or increase depending on the growth of the town.

The dual allotter normally has ten line-finders associated with each of its two units. If trouble occurs in either unit then all 20 line-finders can be transferred to the remaining unit. When the maintenance man wishes to work on this troublesome unit, or for routine checking, he need only flip a double-throw key to the proper position and thereby busy-out that unit and place the 20 line-finders on the other unit.

The reverting call circuit is designed to allow two subscribers on the same line to call one another by dialing a special number consisting of a preliminary digit followed by the last digit of the calling subscriber's number and the last digit of the called subscriber's number. The calling party then hangs up and both subscribers' bells ring. When the call is answered the bells cease ringing and the calling party is thereby informed.

Connectors may be of various types depending on the kinds of service which they are to perform. These services are party-line ringing of either the harmonic or code types, *PBX* trunk hunting, conversation timing from one or both ends, and reverting call by directory number. This method of reverting call is different from the above, in that the calling party dials the called party's number. Upon receiving busy tone, he hangs up his receiver. After an interval which he assumes is sufficient for the called party to have answered, he again removes his receiver and conversation commences provided the called party has answered. The busy verification switch train allows an operator or wire chief to verify the busy or idle condition of a particular subscriber's line.

The features of the *XY* switch and system that make it readily adaptable to dial telephone exchanges of all sizes and possible growths are

1. The universal nature of the switch.
2. Its compactness, being smaller than any other switch.
3. Its bare wire multiple which yields economies in wiring.
4. Its package-type units which readily allow for exchange growth and standardization.
5. Its plug and jack-mounted units which give flexibility and provide for fluctuations in traffic conditions.

Electrical Essay

This electrical essay is presented for the recreation of the reader. The author's challenge is: Can you find the error in the reasoning accompanying the following example?

An engineer wishes to measure the core loss in a small transformer that has two 110-volt coils on the low voltage side. The only supply voltage available is 220 volts of the proper frequency. The only wattmeter available has a voltage circuit that is rated at 150 volts and has a resistance of 1,000 ohms. In order not to overload the voltage circuit, the engineer connects the transformer and the wattmeter as shown in Figure 1.

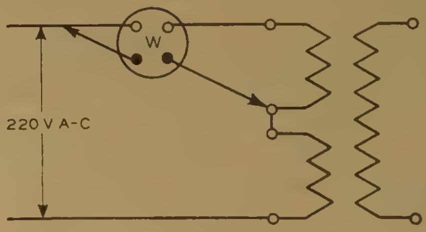

Figure 1

The wattmeter reads 20 watts. The I^2R loss in the current coil and in the transformer may be neglected.

The I^2R loss in the voltage circuit is $(110)^2/1{,}000 = 12$ watts. However, as the one voltage lead is on the line side of the current coil, the engineer reasons that no error is caused by the loss in the voltage coil. He says that the core loss is twice the wattmeter reading or 40 watts. Is this correct?

GEORGE V. MUELLER (M '35)
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Electric Gauges in Quality Control

JOSEPH MANUELE
MEMBER AIEE

The history of measurements is the history of civilization. As man has become able to measure more accurately, he has been able to manufacture more intricate and accurate mechanisms. The use of electric circuits for determining and controlling the quality of products produced by industry has just begun. There remain many problems to be solved; but electric gauges already have proved themselves to be a major advancement in the science of measurements and quality control.

MAN took his first step on the long road to civilization when he first became aware of his surroundings quantitatively. His early measurements were in terms of natural phenomena. A mountain peak, or a favorite valley full of game, was "three moons" away. Later he used parts of his body as standards of measure. A royal edict defined a rod as "the length of the left foot of 16 men lined up as they left church on Sunday morning", and an inch was the length of "four barley corn laid end to end".

Man's progress from life in a cave to luxury in a steam-heated apartment has been in cycles. First, he developed some crude tools, and with these tools he mined, refined, and fabricated a few metals—gold, silver, and copper. With metals, he made himself more serviceable tools with which he was able to fabricate still harder, stronger, and more efficient metals. But soon he found that the simple tools like the wheel and the plane were not sufficient to supply the needs of a civilization growing more complex with each passing generation. He then developed mechanisms to do his work and to help him win his wars.

A mechanism is an assembly of parts to form a unit capable of transmitting power or executing a complicated movement. The parts must fit together more or less perfectly—the more perfectly fitting the parts are, the more efficient the particular mechanism becomes. Hence, man found, early in his career, that very often his progress was impeded by his inability to measure with any degree of accuracy the parts he was making. The development of the steam engine was retarded due to the difficulty of producing round cylinders. James Watt was literally elated when he was informed by his partner that cylinders had been produced "round to within the thickness of a shilling". This was progress.

Measurement is a science, and man's development of his ability to measure marks the rate of his scientific progress. As man became able to measure a phenomena or parts he was working with, he was able to replace art by science.

Man took his greatest step forward in his ability to measure mechanical parts when he invented the screw micrometer. With this tool he was able to measure to a thousandth of an inch, and the manufacture of interchangeable parts became possible. This introduced mass production and brought about new economies in manufacturing. This mass production of products at a cost within reach of everyone raised the standard of living several index points and brought man new leisure, more time to experiment and develop still more accurate and complex tools.

But, with the development of the screw micrometer and the vernier caliper, man had reached the limit of his ability to measure mechanical parts in mass production. He needed a more sensitive measuring tool, if he were to make still more accurate parts. His first recourse was to light, and he made use of a beam of light as a multiplier to magnify measurements so he could determine them with greater accuracy. Figure 1 shows a gauge which makes use of a light beam to obtain accurate magnification for making accurate measurements. With this gauge, a multiplication of 10,000 to 1 is possible. However, magnification by means of a light beam has practical limitations not possessed by the magnetic cir-

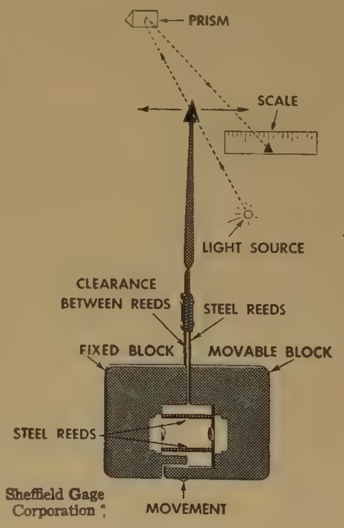


Figure 1. A typical application of the electric light to obtain magnification and increase the accuracy of a gauge

Sheffield Gage Corporation

Essentially full text of miscellaneous paper **47-46** "Use of Electric Gauges in Quality Control," presented at the AIEE winter meeting, New York, N. Y., January 27–31, 1947.

Joseph Manuele is the director of quality control at Westinghouse Electric Corporation, Pittsburgh, Pa.

Pratt and Whitney

Figure 2. Electric gauges can gauge 5,000 feet of sheet steel per minute

cuit or electronic amplifiers, so man turned to electricity to give him the magnification in measurements which he desired.

For purpose of magnification and making possible more accurate measurements, electricity can be used in any one of four forms, or any combination of these:

1. Electric light sources can be used to obtain magnification in conjunction with mirrors and lenses. (Figure 1)
2. The magnetic field can be used so that displacement of an armature will cause an unbalance in the magnetic circuit which can be read on a suitable calibrated millivolt meter. (Figure 2)
3. Electronic tubes can be used in an amplifying circuit much like the conventional home radio receiver.
4. Wave energy, in various forms, is used for measuring the thickness or size of parts. X rays are used in the instrument shown in Figure 3.

Magnification, by means of the magnetic circuit, may not appear to be very feasible at first glance. However, from analysis of the principle of the step-up transformer or the Wheatstone bridge it readily can be seen that an electric circuit can be developed to achieve any magnification desired. The electric circuit used in electric gauges generally consists of two balanced magnetic coils, with an armature between them. The gauging member displaces this armature, thus upsetting the balance of a Wheatstone bridge type of circuit which is reflected as an indication on a suitably calibrated voltmeter.

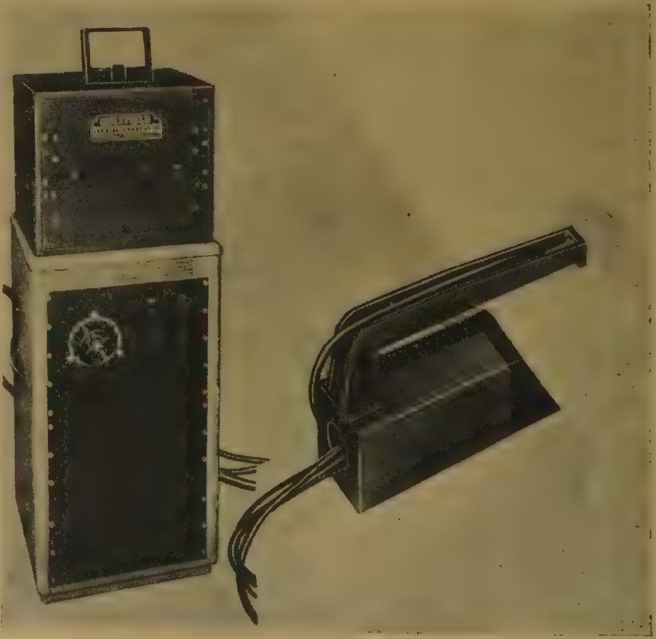
The electric gauge can be made to multiply, without distortion, in ratios as high as 20,000/1. These gauges can be made to read directly to 0.000005 inch on the dial. They are rugged and will maintain their accuracy when properly used.

However, the most valuable use of electric gauges is not for the determination of a dimension after a part has been finished, but for control of the production of that dimension.

Figure 4 shows an electric grinder gauge which, when installed on a grinder, tells the operator how fast stock is being removed. All the operator has to do is adjust his gauge by means of a master and start the grinder. His duties after that consist of loading and unloading the work in the grinder, and placing the gauge head over the work. By use of the gauge and solenoid, the correct size is produced, regardless of the accuracy of the grinder, provided the grinding wheel is kept properly dressed. The size is controlled by the gauge acting directly on the dimension being processed. Use of this gauge makes possible production of journals within tolerance of 0.0001 inch, with no scrap. This gauge really controls quality.

The same electric circuit can be used in gauges for the continuous gauging of material, such as steel strip. The steel strip, or sheet, may pass through the gauge at 5,000 feet per minute, and the gauge will give an accurate indication, on a dial, of the thickness of the sheet. This allows the operator to make proper adjustments to the mill so that the sheet thickness is controlled within the required tolerances.

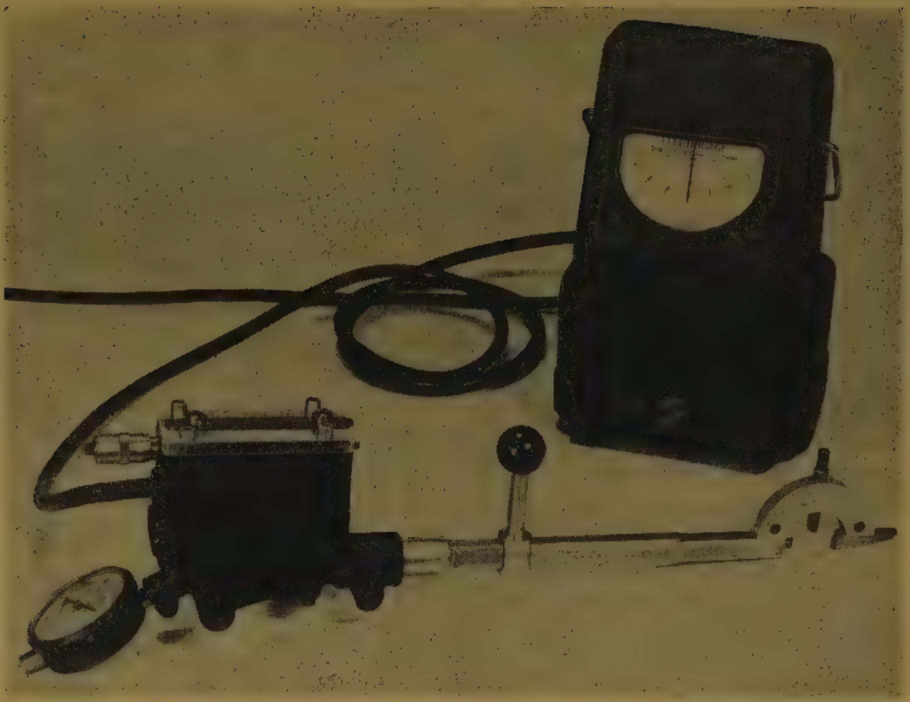
More recently, an electric gauge has been developed which does not touch the material being gauged. This gauge, shown in Figure 3, makes use of X rays for com-



Sheffield Gage Corporation

Figure 3. This gauge uses X rays to measure the thickness of parts without touching them

Figure 4. This electric gauge controls the size to which a shaft is ground



Westinghouse Electric Corporation

paring two thicknesses. The X rays are split into two streams. One of these streams is made to pass through a "standard" and then is picked up by a photoelectric cell. The other stream is made to pass through the specimen being gauged and then is also picked up by another photoelectric cell. Both of these photoelectric cells are connected to a suitable indicating instrument. If the amount of rays picked up by each cell is the same, the indication on the instrument is zero. If one cell picks up more or less rays than the other, indicating a thinner or thicker part, the indicating hand is displaced accordingly.

This gauge will compare the thickness of any two parts which can be placed in the path of the X-ray stream. Steel sheets, glass, mica, and textiles can be compared readily. The kind of material, its hardness or texture, is of no consequence.

The use of electronic circuits as multipliers has made possible development of gauges and measuring instruments for applications not considered possible ten years ago. For example, a few years ago, there were no means of measuring the degree of roughness of a machined or ground surface. Engineering specifications generally described a surface to be "ground smooth", or simply "smooth". Generally, neither the engineer nor the inspector had any real conception of what was wanted. Consequently, true standards of roughness were impossible of either specifications or attainment. Today, a number of gauges, employing electric circuits, are used for measuring the average deviation, or, in some cases, the actual deviation of the hills and valley in a surface from a nominal line indicating the true surfaces. Such instruments generally are sensitive to deviation as low as a quarter of a millionth of an inch. Instruments of this type usually use electronic tube amplifying circuits, similar to those in the conventional home radio receiver, for obtaining proper magnification. The output may be viewed on an oscilloscope.

The development of electronic tubes for use in amplifying circuits has made possible the building of special automatic gauging equipment which gauges parts faster and more accurately than ever could be done by the most skilled inspector. The gauge makers and consulting firms have accumulated a fund of knowledge and talent which enable them to design and build automatic gauges, employing electric circuits, for almost any purpose. Classifying gauges will separate parts into classes according to size, for purposes of selective assembly, at a fraction of the cost required by hand methods.

Electric circuits are not subject to fatigue and the judgment of an electronic tube amplifier will not vary as is the case with even the best inspectors. Today, by employing properly designed electric circuits, dimensions, roughness of surfaces, colors, hardness, and many other properties which only a few years ago were subject to the vagaries of human judgment can be measured on a continuous scale.

The use of electric circuits for determining and controlling the quality of products produced by industry has just begun. A number of problems still remain to be solved. Although the mass spectrometer is in wide use, the problem of measuring odors is not yet solved. The analysis and measurement of noises has not been satisfactorily solved. A noise is composed of a number of frequencies, some of which are pleasant to the ear, and some of which are disagreeable. The separation of these frequencies, in order to enable us to apply measures for the elimination of the disagreeable ones, is an important problem facing the builder of domestic electric appliances, such as refrigerators, fans, and electric clocks. Here is a challenge to the manufacturer of noise measuring equipment.

While colors can be classified in the laboratory by use of the spectrophotometer, no satisfactory portable instrument exists today for effective color matching in the shop. The matching of colors on automobile elements, refrigerator elements, textiles, papers, and many other parts is a problem industry would like the instrument makers to investigate. These instruments should be portable, rugged, and capable of being operated by relatively nontechnical people.

The future application of electric instruments in the exploration of hidden defects, such as X rays, and the use of gauges for actually controlling machining and grinding operations may be expected to increase.

At present, there is no other tool which can adequately replace wave energy, such as X rays or supersonic instruments for locating and exploring hidden defects in castings, forgings, and molded parts. However, the necessity of taking and developing a picture makes the use of X rays slow and costly. Fluoroscopic methods will need to be developed to a greater extent than they are at present, if X rays are to be used to control quality. At present, X-ray examination and the use of supersonic instruments are both post-mortem operations and cannot be used to control quality. They are used only to discover unsatisfactory units in a lot after the units are completed. Corrective measures can be taken only on subsequent production.

The forming of parts by removing material, such as in machining and grinding operations, will call for the use of electric gauging, and controlling of the feeding of the tool into the work. The removal of material will be measured and controlled by the gauge. Operations thus will become truly automatic and electricity will really become man's servant.

Motor Selection for a Rolling Mill

L. H. BERKLEY

The methods of analysis and calculations outlined for a small brass-slab rolling mill can be applied to other installations. The time and money spent selecting the proper motor size saves extravagance in first cost, maintenance, and power factor correction.

THE brass-slab rolling mill (Figure 1) was originally driven by a Corliss steam engine attached to the flywheel shaft. In 1917 a 250-horsepower 580-rpm 2,200-volt 3-phase 60-cycle 57.5-ampere squirrel-cage induction motor replaced the steam engine and the additional reduction gears were added. Recently replacement for this motor was considered advisable.

In considering the purchase of a new motor, four possibilities were apparent:

1. Standard squirrel-cage induction motor similar in characteristics to the old motor (National Electrical Manufacturers Association class *A*).
2. High-slip squirrel-cage induction motor (NEMA class *D*).
3. Wound-rotor induction motor.
4. Synchronous motor.

Before a decision was reached, the torque–speed characteristics of each motor had to be considered. Because of its expensive first cost and maintenance, the wound-rotor induction motor was eliminated (its rapid acceleration and variable speed being of no consequence in this application). It was found that an 80 per cent power factor synchronous motor would cost little more than the standard squirrel-cage motor and controls and would consume a leading power of about 150 kva from no load to full load, whereas the induction motor would offer about 100 kva lagging. However the synchronous motor is not adapted to the sustained "jogging" required to remove a slab that may become stuck between the rolls when a coupling breaks. This jogging all would be done on the damper windings of

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Essential substance of paper 47-28, "An Analysis of Motor Selection for Brass-Slab Rolling-Mill Service," presented at the AIEE winter meeting, New York, N. Y., January 27–31, 1947, and scheduled for publication in AIEE *TRANSACTIONS*, volume 66, 1947.

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the motor, which could not be made to stand such severe service.

OTHER POSSIBILITIES

The two remaining possibilities were that of the standard and the high-slip squirrel-cage motors. From the known data of the present motor, its torque–speed characteristics were plotted. Figure 2 shows the characteristics of both induction motors. Before a choice could be made between the two, a load test had to be run and several calculations made. Figure 3 shows the results of the tests on the present motor using the hardest slabs (just prior to annealing). It should be noted that the maximum input, when rolling two slabs simultaneously, is about 300 kw. This represents a peak load of about 325 horsepower or about 30 per cent overload on a 250-horsepower motor.

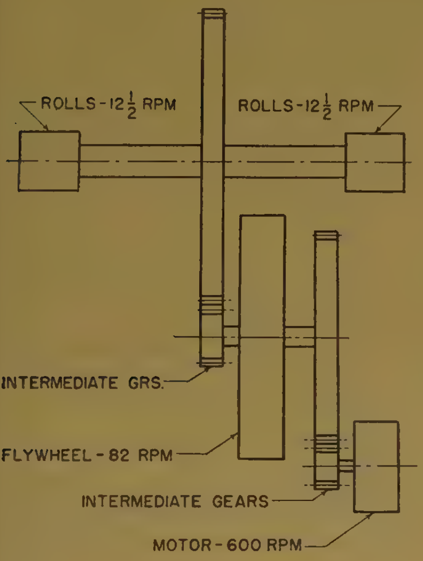


Figure 1. Schematic plan view of the mill

CALCULATION OF EFFECTIVE INERTIA

The inertia of the load referred to the motor shaft may be determined by two methods:

1. By measuring the dimensions of the flywheel, gears, and so forth, and calculating their effective inertia with respect to the motor shaft.
2. By an experimental method.[1]

It was decided to use both methods as a check on each other.

Measurement. To obtain the moment of inertia, it is necessary to calculate the weight and the radius of gyration. The rim only of the flywheel was considered in making these calculations as therein lies about 95 per cent of its inertia. The moment of inertia of the flywheel was calculated to be 795,000 pound-feet-squared. Referred to the motor shaft this is 14,900 pound-feet-squared (the effective inertia at the motor shaft is inversely proportional to the square of the speed ratio).

Experimental Method. By well-known methods it may be derived that

$$WR^2 = 21.65 \times 10^5 \times \frac{P_F}{S \times (\text{rpm per second})}$$

where

WR^2 = effective inertia at the motor shaft including that of motor rotor in pound-feet-squared.
P_F = power required in kilowatts to overcome the friction in the motor and load when running at a constant speed S.
S = the motor speed at which P_F is measured.
Rpm per second = the initial rate of retardation of the motor when the driving power is removed.

The effective moment of inertia of the load is 15,900 pound-feet-squared.

The result obtained by the experimental method is 1,000-pound-feet-squared larger than that obtained by measurement. The difference is due to the flywheel spokes and the gears of the system which were not considered in measurement. In further calculations, the effective inertia of the load was taken as 15,900 pound-feet-squared. Also, the motor rotor and flywheel were considered as rigidly coupled, that is, they accelerate and decelerate simultaneously.

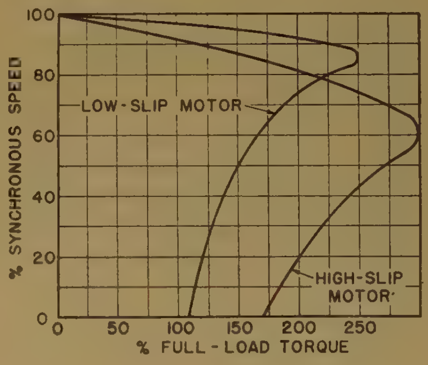
FLYWHEEL EFFECT OF THE LOAD

Before the proper slip of the motor could be selected, it was first necessary to calculate the effect of the flywheel, that is, the power it generates when the motor slows down. A formula to calculate this power was derived:

$$HP = 3.102 \times 10^{-7} \frac{WR^2(S_1^2 - S_2^2)}{t}$$

This formula represents the average horsepower developed by the flywheel during the deceleration period of t seconds. Although the instantaneous horsepower will vary considerably during the load peak, the average value is useful to determine the relative effect of the flywheel by comparing with the peak motor load. The

Figure 2. Typical torque–speed curves of squirrel cage induction motors



average power generated by the flywheel during the rolling operation (2 slabs) was 70 horsepower. From the load curve, it is seen that the peak input to the motor when rolling two slabs is approximately 300 kw, which represents about 325 horsepower. The 70 horsepower which is contributed by the flywheel is 22 per cent of the peak.

However, this alone does not tell the complete story. It is necessary to compare the relative energy contributions of the flywheel and the motor. The energy contribution of the flywheel is 95,000 foot-pounds. The energy contributed by the motor may be calculated by measuring the area under the motor power curve in kilowatt-seconds and then converting it to foot-pounds. Assuming 70 per cent over-all motor efficiency, the energy supplied by the motor is 526,000 foot-pounds.

The energy contributed by the flywheel is about 18 per cent of the energy which is delivered by the motor.

MOTOR CHARACTERISTICS

After the tests and calculations had been made, it was felt that some consideration of basic principles would help in making an intelligent choice between the low-slip and the high-slip motor. In rolling and punch press applications having a flywheel, the high-slip motor usually is used because

1. Fuller utilization is made of the flywheel as it is given a chance to release more of its kinetic energy when the motor speed decreases during the load peak. This reduces the peak horsepower required of the motor and therefore the rms horsepower and horsepower rating. It should be remembered that the energy released by the flywheel is restored to it when the motor speeds up again, so that regardless of which type of motor is used, the total energy delivered by the motor remains unchanged. Also, it should be noted that the flywheel has expended its usefulness when the torque of the motor becomes equal to that of the load and the motor speed becomes constant.

2. The gears between the motor and the flywheel need not be designed to carry as great a peak load since more of the power required will be contributed by the flywheel. This often results in a considerable saving when a new piece of equipment is being designed.

3. The peak current will be reduced, thus reducing the voltage drop and lamp flicker. In new installations, smaller peak currents mean a reduction in feeder size.

Upon measuring the motor speed with a hand tachometer, it was found to be substantially constant over the middle portion of the rolling period. During this period, the flywheel has very little effect and the motor carries most of the load itself. In other words, the motor torque is almost equal to the load torque and the flywheel contribution is very small. From the previously calculated percentages of the horsepower and energy contributed by the flywheel, it is possible to construct the approximate horsepower–time curves (Figure 5) for the power required to roll two slabs (slab load), the power contributed by the motor (motor load), and the power contributed by the flywheel (flywheel power). The friction power is neglected. Upon inspection of these curves, it may be seen that after two or three seconds from the time rolling starts, the power contribution of the flywheel is very small and the motor must carry most of the load itself. Therefore, with a motor having $3^{1}/_{3}$ per cent slip at full load, the flywheel does very little toward reducing the load peak.

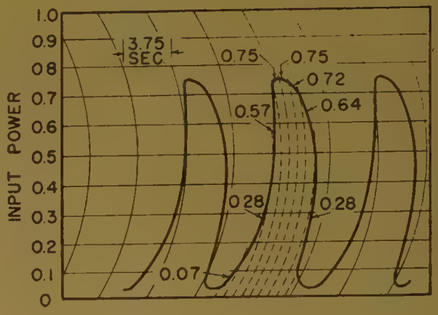


Figure 3. Load test of present motor rolling two slabs

Multiplying factor = 400

EFFECT ON LOAD CURVES

The effect of the high-slip motor on the load curves is shown in Figure 6. This motor would have a full load speed of about 560 rpm (7 per cent slip). Comparing the curves with those obtained using a low-slip motor, the following is noted:

1. The maximum horsepower developed by the flywheel, as well as its energy contribution, is considerably greater. The high-slip motor will slow down at least twice as much as the low-slip motor, allowing the flywheel to contribute at least twice as much energy to the load, or about 36 to 40 per cent of the motor load. The flywheel, therefore, reduces the peak of the motor load and also reduces the pull-out horsepower required of the motor.

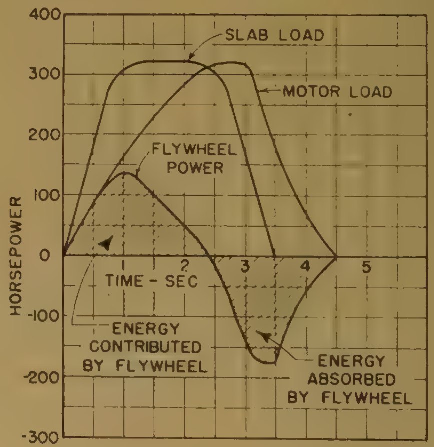


Figure 4. Horsepower–time curves using a low-slip motor

2. The duration of the motor load is considerably longer as more energy must be restored to the flywheel and a considerable percentage of this energy cannot be restored until after the slab leaves the rolls and the motor gets a chance to speed up.

3. The duration of the slab load will be slightly longer and its maximum value slightly lower because the high-slip motor will

operate at a slightly slower speed. The difference in each case being only about 5 per cent, this does not represent any serious decrease in production.

4. The areas under the slab load curve and the motor load curve are the same for each motor.

To compare the continuous load curves of the two motors, the high-slip motor load curve of Figure 6 was approximated. It is important to note that the curve is much smoother and that it has a lower peak. Also, the areas under both curves for the same number of slabs are equal, and since the time will vary but a few per cent, the average values will be the same.

MOTOR SPECIFICATIONS

In order to compare the costs of the high-slip and low-slip motors, it was necessary to determine the complete motor specifications for each case, the horsepower rating, pull-out torque, and slip being the most important.

The other specifications—synchronous speed, time rating, voltage, frequency—are fixed, while the starting torque is relatively unimportant.

Low-Slip Motor. The rms horsepower calculated to be necessary was 210 horsepower. It was considered safe to use a 200-horsepower motor because the mill is idle for short periods of time when the slabs are transported from the receiving to the feeding end, rolls adjusted, or time spent waiting for slabs.

The maximum power required was approximately 325 horsepower. As the standard low-slip NEMA class *A* motor usually has a pull-out torque of about 250 per cent full load torque, the pull-out horsepower of such a motor will be about 425 horsepower (assuming 15 per cent pull-out slip) and will be capable of easily carrying the peak load.

The slip of the motor will be specified at approximately $3^1/_3$ per cent.

The complete motor specifications are therefore:

200 horsepower, 580 rpm, continuous duty, open type, 40-degree-centigrade temperature rise, pull-out torque not less than 250 per cent full load torque.

High Slip. The rms horsepower was calculated to be 159 horsepower. A continuous rating of 150 horsepower was chosen. The pull-out torque of NEMA class *D* motors is well above that required by this installation.

The complete motor specifications are

150 horsepower, 560 rpm, continuous duty, open type, 40-degree-centigrade temperature rise, pull-out torque not less than 350 per cent full load torque, 2,200 volts, 3 phase, 60 cycles.

CONCLUSION

Investigation of the two remaining possibilities revealed that a 150-horsepower high-slip motor would cost about 15 per cent more and would be larger than a 200-horsepower low-slip motor. In a new installation, the savings explained in "Motor Characteristics" would more than offset the additional cost of the motor, and the decision would unquestionably be in favor of a high-slip motor.

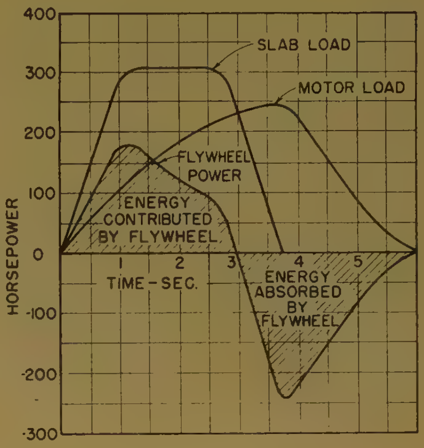


Figure 5. Horsepower–time curves using a high-slip motor

It can be seen, however, that since the gears were already built and the feeders and transformers installed, none of the three reasons are applicable in this case. In view of these considerations, and also the fact that delivery time on the high-slip motor was quoted as twice that of the low-slip motor, it was decided to use a low-slip motor.

The methods and calculations explained in this article may be adapted to many different types of applications involving both new and existing installations.

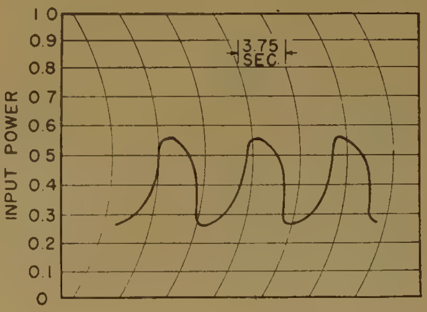


Figure 6. Predicted load curve of high-slip motor

Time spent in determining, as accurately as possible, the motor size required by a given application is well worth while. Excess horsepower on any induction motor drive is expensive in first cost of motor and control and often entails an additional expense of power-factor correction.

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1. How to Determine *WR*^{2} by Running a Simple Test, **L. H. Berkley.** *Product Engineering*, December 1942, page 704.

A 3,000-Horsepower Diesel-Electric Locomotive

D. R. STAPLES T. L. WEYBREW C. A. ATWELL
MEMBER AIEE

The largest Diesel-electric locomotive to be built in a single unit recently has been placed in service. Each of the eight driving axles has its own traction motor. As a result the same locomotive may be used economically in either high-speed passenger service or freight service in mountainous territory by changing the traction motor gearing, a simple shop job.

A 3,000-horsepower Diesel-electric locomotive recently completed by the Baldwin Locomotive Works and the Westinghouse Electric Corporation and tested for the Seaboard Air Line Railway is of the articulated truck type. The two main truck frames are connected at the center of the locomotive by means of a flexible hinge. The two swivel trucks have two axles each and are located at the end of the locomotive. They are connected to the main truck frame by means of center pins. Eight traction motors are used to drive four axles on each of the main trucks. Couplers for pulling the train are carried on main truck frame castings which extend to the end of the locomotive. The truck at each side of the locomotive structure is built up of welded structural shapes. Partitions separate the operating compartment and equipment compartments which are contained in the cab. Main trucks on center pins and spring-plunger-type side bearings support the cab.

Each of the two 1,500-horsepower Diesel engines which constitute the power plant is of the 4-cycle type, having eight cylinders in line, and is equipped with an exhaust-gas-pipe Buchi supercharger. Each engine is rated at 625 rpm and drives a direct-connected generator. Each generator in turn furnishes power to the four traction motors mounted in the truck directly below each power unit.

FEATURES OF THE LOCOMOTIVE

The main truck frame carries the couplers for hauling the train in order that the stresses resulting from pulling and bumping the train may be absorbed by the main truck rather than the cab structure. The main truck frames are connected at the center of the locomotive. The truck frames are heavy cast-steel structures and the stresses do not produce high deflections. The cab structure, however, is of relatively light construction.

Many electric locomotives operating in the United States use a truck arrangement similar to the one used

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Essential substance of paper 47-36, "A 3,000 Horsepower Diesel-Electric Locomotive For the Seaboard Air Line Railway," presented at the AIEE winter meeting, New York, N. Y., February 27–31, 1947, and scheduled for publication in AIEE *TRANSACTIONS*, volume 66, 1947.

D. R. Staples is employed by the Baldwin Locomotive Works, Eddystone, Pa.; **T. L. Weybrew** and **C. A. Atwell** are both with the Westinghouse Electric Corporation, East Pittsburgh, Pa.

here. The traction qualities of this locomotive are recognized to be of the best, thereby reducing the load and stresses to the rails and the maintenance required on the road bed.

On this locomotive, the weight per axle is approximately 50,000 pounds. This low figure results from the large number of axles and is very desirable in order to reduce stresses on the rails, particularly at high speed.

Because the large number of axles also permits the application of eight traction motors, the locomotive was designed so that by changing the traction-motor gearing it could be used either in high speed service or in heavy freight service. For example, when equipped with gearing for heavy freight service, the locomotive developed a tractive effort of 85,600 pounds with a maximum locomotive speed of 65 miles per hour. Gearing can be supplied for a maximum speed of 120 miles per hour and a continuous tractive effort rating of 44,000 pounds. Intermediate gearing is also available.

In this type of running gear, there is practically no transfer of weight from one axle to other axles when starting a heavy train. This permits each axle to develop a full adhesive tractive effort that results in the locomotive developing the maximum tractive effort for starting the train.

The water and fuel oil tanks are located in the base of the cab structure, which permits the application of very large capacity tanks. This locomotive is provided with fuel tank capacity of 3,500 gallons and water capacity of 2,500 gallons. These large-capacity tanks should fulfill the requirements of almost any railroad; however, if the need should arise, this type of design permits the application of larger tanks. The fuel oil tanks, located in the cab frame, are protected by the main trucks from damage due to minor accidents and articles thrown up from the road bed.

The equipment can be arranged in the cab so that the train heating boiler is located adjacent to the operating compartment. In this location, the fireman can control and observe the operation of the boiler, without leaving his operating position.

Two 3,000-horsepower locomotive units can be connected to obtain a 6,000-horsepower operating unit. The running gears of the two 3,000-horsepower units can be connected with a permanent draw bar; the cab of the two units can be connected with any of the usual flexible connections.

The ratio of horsepower to unit length of this locomotive is the highest of any on record.

THE GENERATING UNIT

The generator is mounted on the Diesel engine bed which is resiliently supported on the locomotive frame. The rotor is bolted to the flanged end of the engine crankshaft and is supported by the engine's main bearings and the single generator bearing at the commutator end. A vee-belt drive from the generator shaft is used for the exciter-generator unit mounted on the top of the main generator.

The air compressor also is driven, through a flexible coupling, by the generator shaft which extends beyond the bearing. The engine turbocharger is mounted on top of the main generator to the left of the exciter-generator unit. (See Figure 1.)

Simple construction is employed which produces a strong rigid frame. The generator frame is rolled from plate and butt-welded to form the barrel. The bearing and brush holder support is formed by a plate welded into the barrel. The roller bearing is carried in a cartridge bolted to the end of the plate. Removal of the rotor from the frame does not necessitate disassemblement of this cartridge, which therefore must be opened only when inspection and repair of the bearing itself is carried out. The bearing is of the double-spherical self-aligning type. Ample labyrinths are provided in the inner and outer caps to prevent the escaping of grease from the bearing.

In contrast to the usual side-supported brush holders, here they are supported at the end of the brush box. The space around the commutator is less obstructed and the brushes are more accessible for inspection and

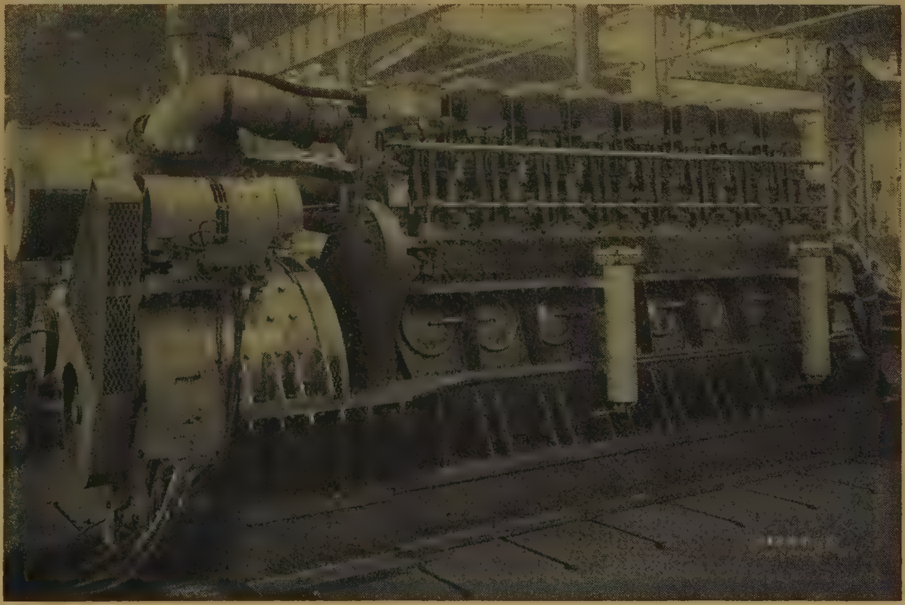

Figure 1. The 1,500-horsepower power plant undergoing load tests

maintenance. Double brush holders are used, having two narrow brushes side by side, each brush having its own pressure finger. This design results in better contact between the brushes and the commutator than obtained with single wider brushes, and reduces commutator maintenance.

Power is supplied from the storage battery to operate the generator as a separately excited motor in starting the Diesel engine. During this time, most Diesel locomotive generators are excited by a series winding on the main pole, which is used only for this purpose. Here the main field winding is used for excitation during the engine's starting, and the generator therefore is smaller in diameter and lighter than otherwise would be possible.

The exciter–generator unit operates at 3.6 times the engine speed and consists of two machines mounted in a single frame assembly. A single shaft with the two rotors is carried on two roller bearings, one of which is a thrust type. Between the two rotors is mounted a dual fan which draws air through the two machines and exhausts it radially through openings in the frame at the center of the unit. The exciter portion of the unit is a 6-pole machine, four poles of which have a single winding separately excited from the storage battery. The other two poles have double windings. One of these is self-excited, being connected across the exciter armature, and the other is separately excited, being connected in series with the main generator armature. The exciter supplies excitation power to the main generator field. This combination of field and a careful design of the magnetic section of the exciter produces a generator output voltage which varies inversely with current and closely matches the Diesel engine loading requirements. The generator therefore is small and light for its rating and speed because it needs no differential winding to produce the desired voltage characteristics.

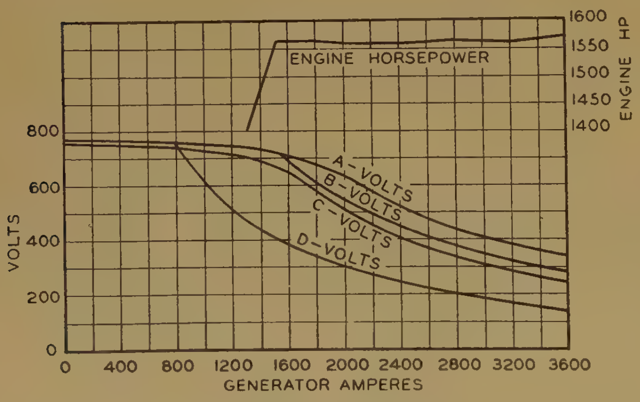

Figure 2. Characteristic curves resulting from engine load control (full engine speed)

Power at 75 volts for lighting, battery charging, and locomotive control circuits is supplied by the generator portion of the exciter-generator unit which has a capacity of 9 kw. This machine is a separately excited 4-pole machine, the voltage of which is held constant by a voltage regulator for engine speeds varying between 250 and 625 rpm.

ENGINE LOAD CONTROL

Figure 2, curve *C*, shows the generator voltage curve which results from the cumulative and opposing fields of the exciter. This curve applies only for full speed, a definite temperature of the generating units, and a particular setting of the exciter field resistance. It is desirable to regulate automatically the load on the engine to match closely the power output as shown by curve *B*. This result is obtained by a carbon-pile rheostat electrically connected in series with the exciter battery field, a pilot valve mounted on and operated by the governor, and a metering valve. Curve *E* shows actual test data of corresponding engine horsepower. Curves *A* and *D* indicate respectively the upper and lower limits of the loading system. Wide variation in engine power is permitted therefore without overloading or underloading the engine.

TRACTION MOTOR

Each of eight traction motors is of the series 6-pole type and is separately ventilated. Its power is transmitted by a spur pinion on the motor shaft to the gear on the axle. The motor has a rolled steel barrel with a cast steel commutator end housing welded to the barrel to form an integral rigid assembly. The pinion end housing is fitted to the barrel and bolted in place, but it can be removed when disassembling the motor. Access to the commutator and brushes is afforded by two large openings, one on the top and one at the bottom.

The brush holders are the usual railway motor type except that the brushes are split to form two narrow brushes operating under a single pressure finger. This construction has lengthened the brush life and reduced commutator maintenance.

The bare motor weighs 7,380 pounds complete, with gearing and has a rating of 650-horsepower output. On this basis, a very favorable ratio of less than 11.5 pounds per horsepower is obtained. This figure is reduced to less than 10 pounds per horsepower when gearing is eliminated from this comparison. Approximately one half this horsepower output per motor is required on this locomotive. Hence, long life and low maintenance are expected.

For use in freight service, high tractive effort is important. The maximum reduction gear ratio includes a 15-tooth pinion which is of conventional design. The pinion is shrunk on the motor shaft and readily replaced when worn. With this gear ratio the motor produces a tractive effort at continuous rating of 10,700 pounds or 85,600 pounds for the locomotive. This is unusually high for a light weight motor using conventional gearing.

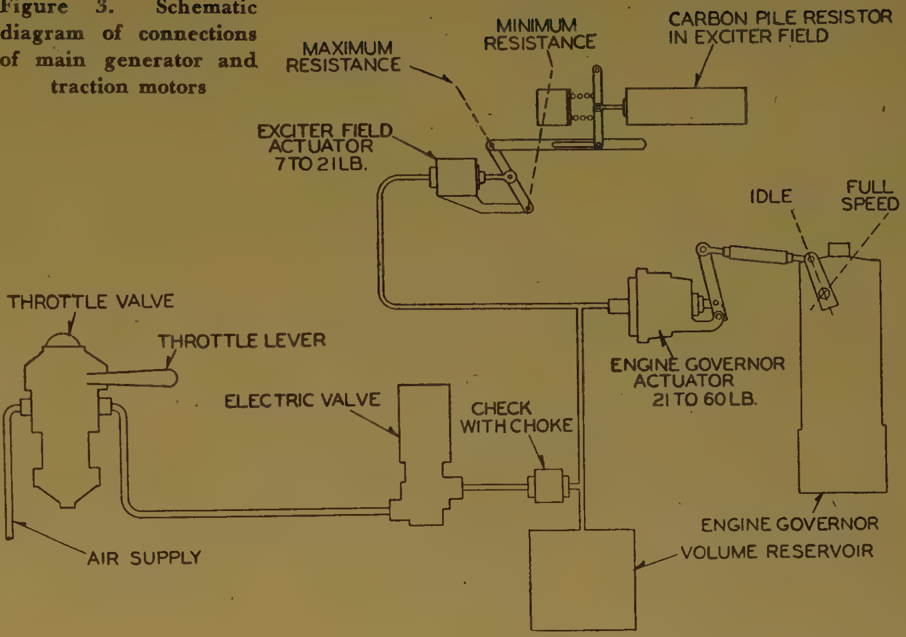

Figure 3. Schematic diagram of connections of main generator and traction motors

AUXILIARY MOTORS

The fans which draw air through the engine cooling radiators are driven by four vertical series d-c motors, each rated 33 horsepower. The fan is mounted on the armature shaft. The two centrifugal blowers which furnish ventilating air to the traction motors are mounted on the floor at the center of the locomotive. Air is forced through ducts in the underframe and sliding joints to openings in the traction motors. The blowers are also driven by series d-c motors.

Motor drive is generally accepted as preferable to a belt drive from the engine for such auxiliaries, but several types of power supply are favored by various locomotive builders. Most of these systems require an extra generator to supply power to the auxiliary motors. On this locomotive, this power is supplied by the main generator, thereby reducing cost and maintenance. The system efficiency is also improved because the main generator efficiency is better than that of a smaller machine. The motors are designed to operate two in series so that the windings are more rugged and less likely to break.

The traction motor blowers operate whenever the engines are running so that the motors are ventilated during locomotive coasting and idling periods. The fan motors operate in three different combinations depending on the amount of radiator cooling required. The proper combination is selected automatically by thermostat switches actuated by the temperature of the engine cooling water. For slow speed operation, the four motors are connected in series. The medium speed is obtained with two motors connected in series, and high speed by shunting the series field sets one half of full strength.

The auxiliary motors are designed for full speed operation at 600 generator volts. (See curve *B*, Figure 3.) If generator voltage rises above 600 volts, the field shunts are removed automatically to prevent overload. This system in conjunction with automatic shutter control regulates the temperature of the engine cooling water very closely under all conditions of load and ambient temperature and without attention from the engineman.

ENGINE SPEED CONTROL

The control of application of power, or as more commonly termed, the throttle, is entirely pneumatic. The throttle valve is designed so that the pressure in the outlet pipe is directly proportional to the movement of the handle. In the idle position, the outlet pressure is zero. In the first power position, the outlet pressure is 7 pounds.

Movement of the throttle valve beyond the first power position operates the exciter field actuator. Operation of the exciter field actuator increases the pressure on the exciter field rheostat, thereby increasing the excitation of the exciter. At 21 pounds the exciter receives full excitation and further movement of the throttle valve operates the engine governor actuator to increase the Diesel engine speed.

This system results in a smooth, even rate of power application, without jerks or sudden changes. It permits the locomotive to exert full tractive effort for starting the train because it is possible more closely to approach the slipping point of the wheels by applying the power at a uniform rate than is the case when the power is applied in large steps. Check valves with chokes and volume reservoirs are supplied in the air line to the actuators. These devices prevent a too rapid increase in rate of applying power which could occur if the operator moved the throttle handle too fast. Such operation tends to produce slipping of the wheels and reduces the tractive effort which the locomotive can develop.

Solenoid-controlled valves are supplied in the air lines. The rapid rise of motor voltage when wheel slippage occurs actuates relays which operate to close a control circuit which in turn energizes the solenoid, thereby shutting off the air supply and exhausting the air line to the governor actuator. The engine speed and the power supplied to the traction motors are reduced. When the slippage ceases, power is reapplied automatically to these motors. With this system, the reduction in power is under control of the Diesel engine governor. This prevents any tendency of the Diesel engine to overspeed which would be the case if the load were removed quickly by such means as opening the electric circuits. Overspeeding of the Diesel engine is likely to trip the engine overspeed governor, thereby stopping the Diesel engine.

This system of wheel slip control reduces jerks and bumps in the train ordinarily caused by wheel slippage. The control of air flow results in a smooth, even reduction in power followed by a smooth, even reapplication of power.

NO TRANSITION

The main electric circuits of this locomotive are extremely simple as shown in Figure 4. Each generator furnishes power to four traction motors. The four traction motors are connected permanently in a series-parallel arrangement. One of the important features of the permanent motor connections is that a perfectly smooth acceleration of the train is obtained. This is not possible when a change from one motor combination to another is used.

The permanent motor connections make it easier for the engineman to operate the locomotive. Only one lever, the throttle lever, is required for complete control of the power of the locomotive.

The series-parallel connection of traction motors also stabilizes the electrical transmission when starting a heavy train. If the wheels geared to one traction motor start to slip, the current through the two motors in this circuit decreases. Because of the constant horsepower characteristics of the generator, a reduction in current is accompanied by a rise in voltage. A rise in generator voltage, however, causes a rise in current in the remaining two motors in the parallel circuit. This rise in current limits the rise in generator voltage and stabilizes the electrical conditions.

Isotope Separation by Electromigration

A method of separating isotopes by counter-current electromigration has been developed by the National Bureau of Standards in connection with work on the natural isotopes of potassium and chloride. This method makes use of the difference in the ionic mobilities of the isotopes of an element, and has been developed to a point where it can be used as a practical means of separating not only isotopes, but ionic species in general.

The entire process takes place within an electrolytic cell containing anode, cathode, and suitable electrolyte. The basic principle of operation of the method rests in an imposed flow of electrolyte through the solution in a direction opposite to the migration of the ions to be separated. If the rate of flow of the electrolytic counter-current is made equal and opposite to the average rate of ion transport, then only the lighter isotopic ions will make headway against the current, while the ions of the heavier isotope are carried in the opposite direction.

In the separation of electrolytic ions, where ion transport can be looked upon as a small forward drift superimposed upon kinetic agitation, it is necessary to reduce the rate of remixing resulting from convection in the electrolyte to a point below the rate of ion separation. Also, to obtain appreciable concentrations of a given isotope, a multistage fractionation process must be employed. Both of these requirements are met by carrying on the electrolysis in a fine-grained packing of uniform porosity. The packing not only reduces remixing to a minimum, but acts as a fractionation column under total reflux.

The process first was used in the separation of the isotopes of potassium. For this purpose an electrolytic cell consisting essentially of vertical cathode and anode compartments (provided with droppers and funnels for addition of H_2SO_4 and KOH, respectively), is immersed in a mechanically agitated constant-temperature bath. The cell also is provided with a funnel for the addition of the K_2SO_4 electrolyte. Electrodes are of platinum gauze. A siphon connects the anode compartment to a constant-level spillover. Addition of further liquid to the solution thus causes a flow of electrolyte through the packing in the horizontal connecting tube toward the anode in a direction opposite to the migration of the positive ions.

The counter-current electromigration method has several inherent advantages over alternative methods of isotope separation that have been used in recent years. The simplicity of the apparatus, both in construction and operation, is perhaps its most important feature. Isotopic separation takes place in a single step without the need of a vacuum system, or other elaborate accessories. The system requires very little attention, and with the use of automatic controls for addition of restituent liquids it becomes entirely self-regulating. The use of a very fine uniform porous packing provides a much higher reflux efficiency per unit length than may be achieved by other fractionation methods of isotope separation. Hence, the assembly has the advantage of requiring a minimum of space for the results accomplished. The process has the added convenience of being well adapted for use with many elements which may be obtained easily in ionic solutions.

Electrostatic Ills and Cures of Aircraft

II. Radio Interference and Its Control

ROBIN BEACH
FELLOW AIEE

In the preceding companion article, the inescapable tendency of an airplane in flight to accumulate relatively heavy electrostatic charge was discussed, with especial reference to loss of communication through resulting radio interferences. In this concluding part, several types of devices for dissipating the static charges on aircraft are described and comparisons given by test results. It is shown that metallic bristles with chemically etched points may be applied so as to bleed off the charges as they form, and thus obviate radio interference and other attendant hazards to a degree heretofore not attained.

THE preceding part of this article has shown that if the electric potential of an airplane could be maintained at practically zero level with respect to its spatial environment at all times, there would be no problem of static radio interference. However, because atmospheric electrifying agencies are present to some degree much of the time that aircraft are in flight, zero potential cannot be achieved fully even with the most sensitive and effective static dissipators, although radio interference can and should be eliminated completely. The relative potential on an airplane rises proportionately with the accumulating electric charges; in the absence of static dissipators, the presence of edges, points, and other areas of sharp curvature causes critical breakdown potentials to develop which initiate ionization of the air and corona discharge to the extent of ultimately controlling the potential rise.

Actually, as the electrification of the airplane increases, the trailing edges of the airfoils, projecting masts and tubes, and burrs on rivet heads and cotter pins, all being sharp although of relatively blunt sharpness as explained in part I, subject the ambient air to higher and higher potential gradients until, when the air begins to ionize, burst-pulse and leader corona promptly start. It is these which develop minute sparks. When these tiny sparks develop under the increasingly high potential gradients, first at the tips of the wings, empennage, and propeller blades, and later, with still higher potential gradients, along the trailing edges of all airfoils, the overpowering parasitic radiations cause noise interference which "hashes" and obliterates intelligible radio communication.

The knowledge of these conditions of the electrophysical principles basic to the various types of ionization and corona occurring at very sharp metallic points provides the fundamental information by which proper design of effective electrostatic control methods intelligently can be conceived, developed, and applied.

PRIOR ATTEMPTS IN CONTROLLING RADIO INTERFERENCE

Earlier attempts at electrostatic control, dating back a decade or so, variously utilized systems of trailing wires. One such method employed a very fine wire a few inches long, which was reeled out or otherwise trailed from the tail of the airplane.

A tiny paper parachute on the end of the wire maintained the desired tautness. The inboard end of the wire was connected to the metal of the airplane structure through a suppressor resistance. The potential gradient at the wire created ionization and caused partial dissipation of the airplane's charge. In addition to being most inadequate in the amount of its discharge, the fine wire was so fragile that its mechanical weakness rendered it impractical.

Other similar methods variously employed trailing wires at the ends of cords, extending into the slip stream from the tails of airplanes, wherein the cords possessed high electrical resistance for the alleged purpose of suppressing impulse oscillations inherent in such types of ionizers. These systems of electrostatic dissipators, too, have proved of little practical value.

Subsequently cotton rope-floss wicks—called "wet wicks"—were attached to the trailing edges of the wings and to the tail. In order to lower the electrical resistance of the fibers of the wick, which otherwise would be insulators, and thus allow ionization to occur at the ends of the cotton fibers, salt-treated glycerine was permitted to drain from small reservoirs into the wicks. It was because of this wetting process that these static dissipators were called wet wicks. These also proved unsatisfactory and impractical for various electrical, mechanical, and maintenance reasons.

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The author wishes to express his appreciation of the assistance given him during his experimental confirmation of basic concepts on ionization phenomena and on radio interference problems, and in conducting his actual tests on the characteristics of electrostatic dissipators. In particular, the assistance in loans of essential test equipment by the Bell Telephone Laboratories and the WOR Broadcasting Company is acknowledged.

THE DRY WICK ELECTROSTATIC DISSIPATOR

During the Army-Navy Precipitation-Static Project, the so-called "dry-wick" electrostatic dissipator was developed. It consists of a rope-floss wick of fine cotton fibers and is about 13 inches long. For mechanical protection it is encased in a flexible black plastic tube of about one-quarter-inch outside diameter. One end of the wick and tube is secured into a conventional electrical lug for convenience and strength in attaching it to the trailing edge of an airfoil. The floss is supposed to project from the other end of the tube about one inch so that the fibers of the floss are free to ionize in the slip stream by virtue of the impressed electric potential gradient between the electrified airplane and the surrounding space. As the fibers are torn loose from the wick by turbulence of the slip stream, frequent trimming of the plastic encasement is required, as a maintenance service, until finally replacement of the wick with a new one becomes necessary.

During manufacture, the floss is treated with a colloidal solution of silver salt in order to render the fibers partially conductive. The resistance of the wick, like its predecessors, intentionally is designed to be high—of the order of ten megohms—for the purpose of introducing an overcritical damping resistance, as an oscillation suppressor, between the free end where the ionization occurs and the metal structure of the airplane to which it is attached.

The agencies sponsoring the dry wick recommend that two or three wicks be attached to the trailing edge of each wing near the tips, also of each stabilizer and of the rudder. Comments have come to the author from pilots and commercial airline engineers, whose company airplanes have been equipped as recommended with the dry-wick dissipators, that the units are apparently ineffectual in controlling radio interference.

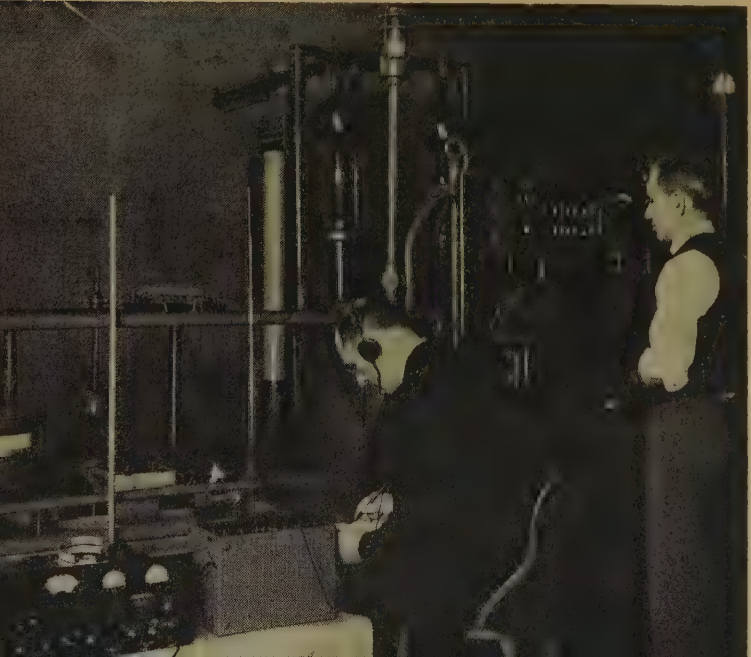


Figure 1. Kenotron power supply, instruments, and radio noise meters employed in obtaining ionization characteristics of electrostatic dissipators and in measuring radio interference when corona 'leaders" develop

IONIZATION AND RADIO NOISE TESTS ON THE DRY-WICK DISSIPATOR

Interested in these comments, the author conducted an experimental investigation into the ionizing characteristics of the dry-wick dissipator. The study included the determination of the voltages at which ionization was initiated, visible corona appeared, leader formation started, and actual spark-over occurred. In these tests noise meters were employed to indicate the relative degree of radio interference, if any, caused by initial ionization, visible corona, ionized leaders, and spark-over.

Two noise meters were used, one a Radio Corporation of America radio-frequency noise meter, type *312-A*, and the other a Hallicrafter ultrahigh frequency communications receiver, type *S-27*. The frequency range of the RCA unit was from 150 kc to 18 megacycles by four scales, and the frequency range of the Hallicrafter unit was from 36 to 165 megacycles by three scales. The antennas of the two noise meters were adjusted to a length of four feet each and each was spaced a distance of four feet from the dry wick under test. The two receivers may be seen in the foreground of Figure 1, the Hallicrafter receiver being the instrument at the left.

The figure also shows the 150-kv kenotron test set and its control panel toward the right, while in the left background the sphere gap, microammeter, and electrostatic voltmeter can be seen. The kenotron set was connected for half-wave rectification and its characteristic voltage-distortion wave, as shown by a cathode-ray oscilloscope, contained some 30 to 40 per cent a-c component. In order to eliminate circuit oscillations, two 175,000-ohm resistors were connected in series with the supply lines to the sphere gap. The voltmeters for measuring the gap voltages were calibrated for peak values of the wave form as used. The microammeter was a D'Arsonval type with which currents could be read to 0.1 microampere and estimated to 0.01 microampere. The scale length was $5^1/_4$ inches.

Throughout the main series of tests, the wick was energized with negative polarity, and the fibers at the end of the new clean wick deliberately were separated and frayed in order to favor their maximum facility of ionization. In actual operation experience has demonstrated that the ends of the wicks soon become matted with oil and dirt and under these prevailing conditions their ionizing capabilities are greatly reduced or practically eliminated. The wick was substituted for the lower sphere of a sphere gap and was connected electrically to the negative line. The 12.5-centimeter upper sphere was connected to the positive line of the ungrounded system.

The ionizing current was measured for voltages which ranged from those at which current first appeared to ultimate values causing spark-over, the tests being conducted for gap settings from 1 to 12 centimeters. These tests were taken during daylight conditions. The ionization curves giving the volt-ampere characteristics of the wick for each gap setting are shown in Figure 2. A study of these discloses some highly significant information concerning the ionizing behavior of the wick under the influence of the impressed voltages.

For example, no ionization current was measurable at the 1-centimeter gap setting until a voltage of 10.3 kv was impressed; 15.2 kv was required for the 2-centimeter gap setting, and 24.5 kv for the 3-centimeter gap setting. For all gap settings of higher values, the wick had the peculiar characteristic of not permitting measurable ionization until the impressed voltage had attained the relatively high value of about 31 kv. Then, when ionization did start at these characteristic high threshold voltages, the ionizing current became of appreciable value suddenly, the initial currents variously ranging from about 1.0 to 5.5 microamperes. Throughout these tests the wick displayed many apparent vagaries and erratic properties in its ionizing behavior.

In order to detect the starting of visible corona, ionized leaders, and spark-over, tests were conducted at night with the laboratory completely darkened. When the appearance of the desired ionizing condition, say visible corona, was first detected, the voltage and current were read by the use of a flashlight. The observer then re-established reasonably dark-adapted vision before repeating the observations and continuing to the next phase of the test. Several observations were made when considerable variation of the meter readings resulted.

The detection of the initiation of visible corona and, also, of ionized leaders was particularly difficult with the wick dissipator. This was largely because of the phenomenon mentioned previously that, when these effects

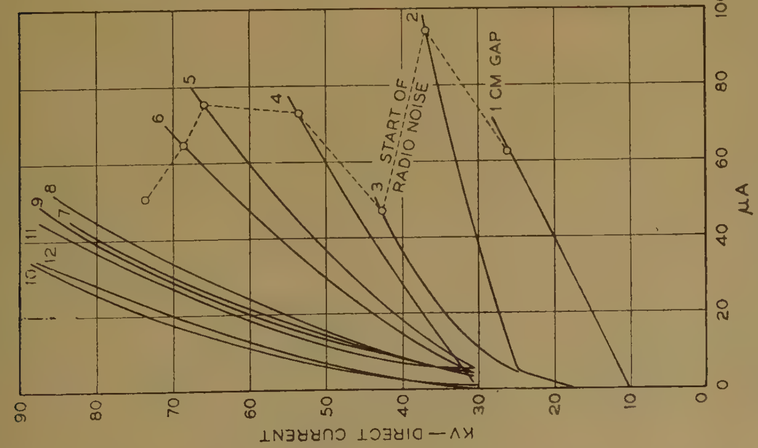


Figure 2. Ionization characteristics for the dry wick

Threshold values of corona "leaders" shown by the circled points at which radio interference starts. Wick negative

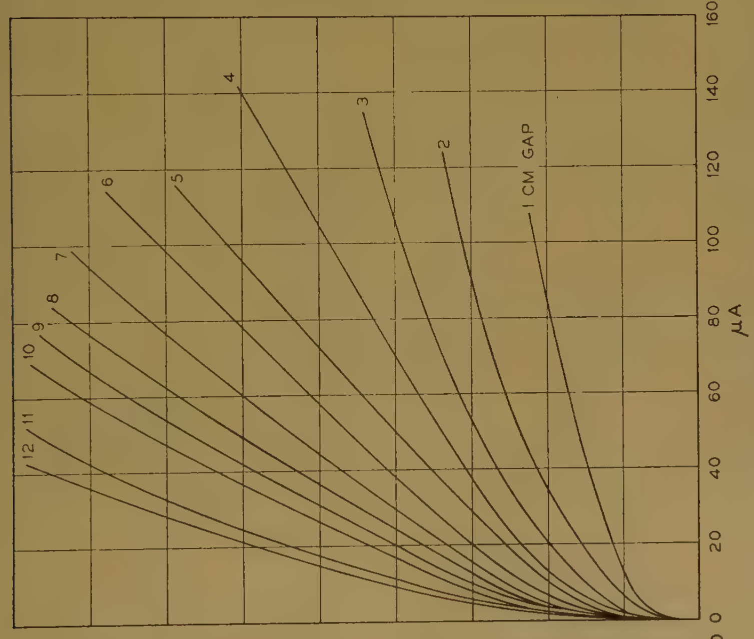


Figure 3. Ionization characteristics for a chemically etched superfine needle

Needle negative

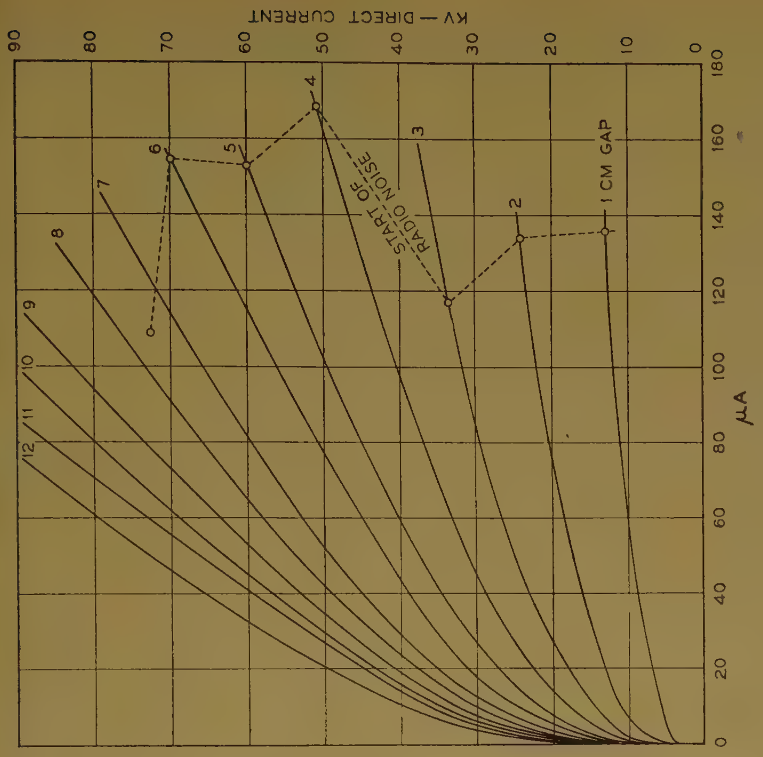


Figure 4. Ionization characteristics for the metallic bristle ionizer

Circled points indicate the threshold values of corona "leaders" and the start of radio noise. Bristles negative

Table I. Voltage, Current, and Noise Measurements at Start of Corona, Leaders, and Sparks

Dry Wick Dissipator Negative

Gap Spacing, Cm	Corona Starts		Leaders Start		Sparking Starts	
	Peak Kv	Microamperes	Peak Kv	Microamperes	Peak Kv	Microamperes
1	13.0	1.50	27.4	75.0	29.9	145
	13.7	1.20	26.8	63.0	26.8	155
	13.35	1.35	24.8	55.0	26.8	155
			25.5	54.0	27.83	151.7
			26.12	61.75		
			3 megacycles—fairly quiet 10 megacycles—fairly quiet 58, 90, 160 megacycles—quiet		3 megacycles—scratching noise 10 megacycles—fairly quiet 58, 90, 160 megacycles—quiet	
2	21.3	7.00	36.8	92.0	55.0	190
	22.2	6.00	36.8	96.0	54.0	188
	21.75	6.50	36.8	94.0	54.5	189
			3 megacycles—bad roaring—90 mv 10 megacycles—bad roaring—50 mv 58, 90, 160 megacycles — buzzing and sanding noise		3 megacycles—extreme roaring and buzzing noise 10 megacycles—treme roaring—200 mv 58, 90. 160 megacycles — very loud buzzing and hashing	
3	26.2	1.50	43.8	56.0	66.2	195
	37.3	26.0	42.8	43.0	64.3	192
	26.2	10.0	41.3	41.0		
	18.5	2.20			65.25	193.5
	19.3	3.00	42.63	46.7		
	16.3	2.00	About the same noise conditions as for the above			
	23.97	7.45				
4	25.4	1.00	54.8	78.0	73.0	175
	32.5	9.10	52.5	67.0	75.0	190
	31.8	8.70				
	34.7	13.0	53.65	72.5	74.0	182.5
	38.8	18.0	About the same noise conditions as for the above			
	37.8	17.0				
	33.5	11.13				
5	25.4	3.40	66.7	71.0	82.0	175
	30.4	7.00	68.7	85.0	82.6	180
	32.4	8.30	62.3	69.0		
					82.3	177.5
	29.4	6.23	65.9	75.0		
			About the same noise conditions as for the above			
6	25.4	2.70	64.3	57.0	90.0	185
	25.8	1.00	70.0	72.0	90.0	185
	25.4	1.20	72.2	65.0		
					90.0	185
	25.53	1.63	68.83	64.7		
			About the same noise conditions as for the above			
8	31.0	1.00	65.6	27.0	93.5	150
	32.4	1.00	68.6	43.0	90.8	143
	31.4	0.50	75.8	57.0		
			84.2	74.0	92.15	146.5
	31.6	0.83	73.0	53.0		
			73.42	50.8		
			3 megacycles—grinding noise 10 megacycles—sanding noise 58, 90, 160 megacycles — buzzing and sanding noise		3 megacycles—terrific roaring—100 mv 10 megacycles—bad grinding noise—10 mv 58, 90, 160 megacycles — mild sanding noise	

Table II. Voltage, Current, and Noise Measurements at Start of Corona, Leaders, and Sparks With Metallic Bristle Ionizer

Ionizer Negative

Gap Spacing, Cm	Corona Starts		Leaders Start		Sparking Starts	
	Peak Kv	Microamperes	Peak Kv	Microamperes	Peak Kv	Microamperes
1	3.98	0.100	13.0	140	13.6	180
	3.87	0.065	12.8	134		
	4.15	0.120	12.9	134		
	4.00	0.095	12.9	136		
			3 megacycles—slightly noisy 10 megacycles— no noise 58, 90, 160 megacycles—no noise		3 megacycles—noisy 10 megacycles—slight noise 58, 90, 160 megacycles—no noise	
2	7.25	0.190	21.6	95.0	29.3	240
	6.98	0.165	22.8	107	29.4	245
	7.03	0.170	25.6	158		
			25.6	158	29 35	242.5
	7.09	0.175	25.5	153		
			24.2	134		
			3 megacycles—noticeable noise—10 mv 10 megacycles—no noise 58, 90, 160 megacycle —no noise		3 megacycles—roaring noise 10 megacycles—slight grinding noise 58, 90, 160 megacycles — sparks cause clicks	
3	11.1	2.35	32.3	102	49 8	230
	11.0	2.20	34.5	126	49.8	228
			33.9	123		
	11.05	2.275			49.8	229
			33.57	117		
			3 megacycles—roaring noise—10 mv 10 megacycles—no noise 58, 90, 160 megacycles—no noise		3 megacycles—roaring noise—10 mv 10 megacycles—grinding noise—8 mv 58, 90, 160 megacycles—clicking	
4	10.4	1.00	51.0	167	59.0	207
	10.7	1.20	51.0	170	59.0	207
	10.55	1.10	51.0	168.5	59.0	207
			3 megacycles—mild roar—6 mv 10 megacycles—no noise 58, 90, 160 megacycles—no noise		3 megacycles—mild roar—22 mv 10 megacycles—grinding noise—15 mv 58, 90, 160 megacycles — clicking noise	
5	13.7	1.55	63.7	173	68.3	192
	14.2	1.75	58.8	152	70.0	203
	12.8	1.20	56.2	135		
	14.2	2.10	60.0	153	69.15	197.5
	13.72	1.65	59.68	153.2		
			3 megacycles—mild roar—13 mv 10 megacycles—no noise 58, 90, 160 megacycles—no noise		3 megacycles—mild roar—7 mv 10 megacycles—grinding noise 58, 90, 160 megacycles — sparking clicks	
6	15.6	1.80	69.7	155	79.4	195
	14.2	1.50	69.7	153	80.4	197
	14.2	1.30				
			69.7	154	79.9	196
	14.67	1.533				
			About same as above for noise conditions		About same as above for noise conditions	
8	19.3	2.40	71.0	107	90.0	185
	19.3	2.60	74.0	111	91.0	187
	19.3	2.50	72.5	109	90.5	186
			About same as above for noise conditions		About same as above for noise conditions	

first made their appearance, the glow-corona and ionized leaders seemed to burst suddenly into an advanced stage. Table I gives the results of these tests together with brief notes describing the degree of radio noise interference at the reference frequencies. The circled points on the curves of Figure 2 indicate the average voltage and current at which the ionized leaders started for each gap setting. Below these points no noise from ionization or from glow-corona was apparent.

IONIZATION TESTS OF A CHEMICALLY ETCHED NEEDLE POINT

To compare the ionizing properties of the dry wick with those of a metallic ionizer, the point of a superfine sewing needle was etched chemically to extreme sharpness. This etched needle then was attached to the top of the lower sphere of the sphere gap by means of a conductive cement. Ionization tests were repeated under the same conditions as for the dry wick and with the needle also of negative polarity.

The family of volt-ampere curves for the needle at consecutive gap settings from 1 to 12 centimeters is shown in Figure 3. The many striking differences between the characteristics of these curves and those of Figure 2 for the dry wick result from the relative differences in the basic phases of ionization by which each performs. Of outstanding prominence is the high sensitivity of ionization with which the needle ionizer responds to the applied voltage, even at very low values. In repeated tests with the needle, the data checked with remarkable agreement, and in consequence the curves align themselves, as would be expected, into their anticipated sequence. To illustrate that ionization started at very low impressed voltages for the various gap settings, the data show that for the 1-centimeter gap the voltage was 2.60 kv peak value, 3.05 kv for the 2-centimeter gap, and only 10.7 kv for the 12-centimeter gap. This property of sensitive low-voltage ionization in copious amount is a most important factor in determining the electrical suitability of properly designed sharp metallic points in a static dissipator.

Ionization tests also were conducted on a single 2-mil spring-brass bristle, the point of which similarly was sharpened to vanishing fineness by chemical etching. The results of these tests were found to be almost identical to those for the etched needle.

THE METALLIC BRISTLE IONIZER

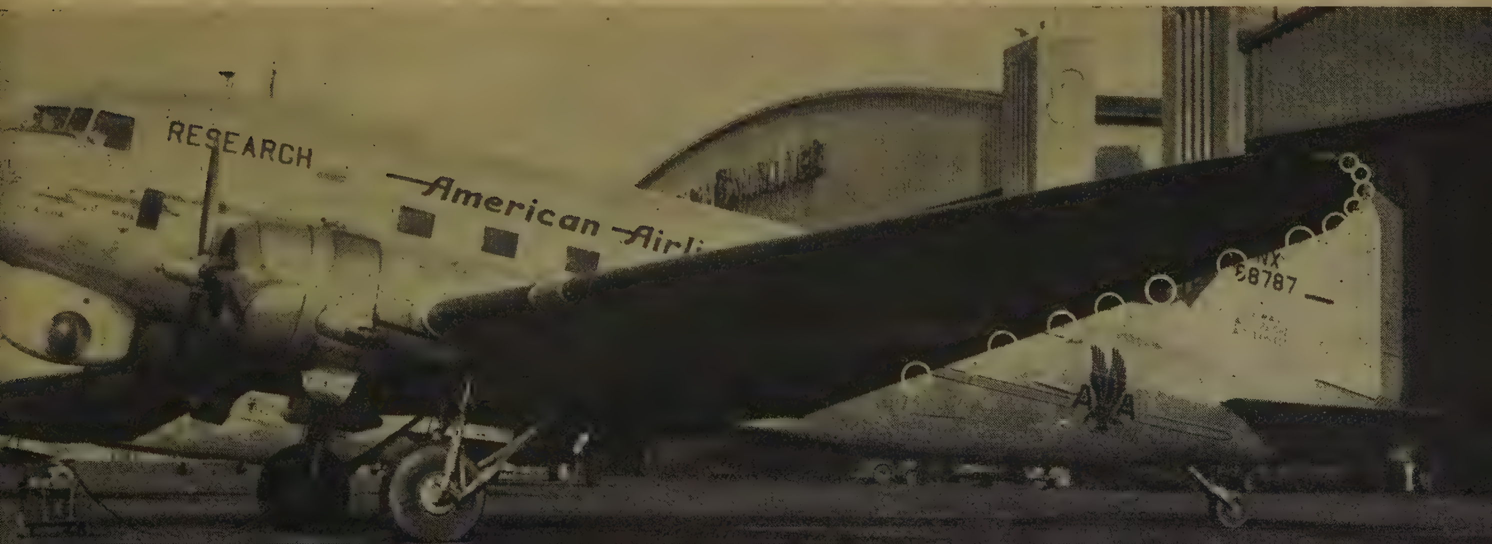
Based upon the underlying design principles of highly sensitive ionizers with which the author has experimented for years and which he has applied with outstanding success in the elimination of static electricity in fire- and explosion-hazardous industrial operations, he also has developed for aircraft service an electrostatic dissipator which even surpasses in many respects the highly favorable ionizing characteristics of the chemically sharpened needle. This ionizer consists of an alignment of several tufts of 2-mil spring-brass bristles whereby the bristles are anchored through holes across the width of a narrow rectangular brass base-plate.

In mounting one of the ionizers onto an airplane, the base-plate is bent over the edge of the airfoil so that the bristles project outward, extending into the slip stream. The plate then simply is secured to the edge of the airfoil by two through rivets. Special conductive cement is applied to the plate before mounting so as to fill the voids between it and the airfoil—partly to provide neat appearance and partly to exclude the collection of oil, grease, and dirt. Also, the cement makes an excellent protective bed for the loops of the bristles on the inside surface of the plate. The points of the bristles are etched chemically to vanishing fineness. The bristles project about $1^1/_2$ inches into the slip stream. The method of mounting and the lay of the ionizing bristles may be seen in Figure 5.

Heavier, shorter, and more resistant bristles whose ends are similarly etched to extreme sharpness are used in units to be mounted transversely to the air flow at the tips of the wings and stabilizers and at the top of the rudder. Thus the sharpened spring-brass bristles possess the excellent ionizing characteristics of a needle but, unlike the needle, are highly resilient, strong, and durable

Figure 5. Metallic bristle ionizer installed for test on the wings and empennage of a DC-3 airplane

The circles show the ionizers as installed on the left wing



without possessing the fragile and brittle properties of a needle and without interfering in any way with the servicing of the airplane. Their life is long and their maintenance nil. Cadmium plating not only preserves the units from common forms of corrosion and weathering but also renders them attractive and inconspicuous.

Accumulations of oil, grease, or dirt do not influence appreciably the ionizing properties of the bristles, as the sharp points are self-cleaning not only by virtue of their ionization activity but also because of the hard, smooth, polished surface of the metal. Even encasing coats of ice formation on the bristles have been found not to inhibit adequate ionization at the points. Actually, the prevailing wet conditions of the metallic ionizer points increase their ionizing sensitivity, causing them to discharge at nearly half the potential gradient when dry. This favorable property, which has been tested by the author and explained with curves by Peek, occurs only on metallic ionizers where their points are supported as separate and discreet ionizing elements as in the metallic bristle dissipator rather than conglomerated into a matted cohesive formation as the wet fibers of the cotton floss wick become.

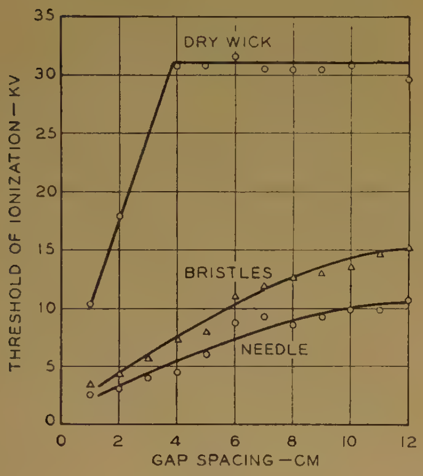


Figure 6. Threshold voltages at which ionization starts at various gap spacings for three types of electrostatic dissipators

IONIZATION AND RADIO NOISE TESTS OF A METALLIC BRISTLE IONIZER

Tests identical in character with those performed on the dry wick were conducted to determine the ionizing properties of the bristle ionizers and also to detect the appearance of the visible corona and ionized leaders as well as to form an appraisal of whatever radio interference developed. The ionization data appear in the curves of Figure 4. These curves, like those for the sharpened needle, are seen to be orderly and in proper sequence, ionization starting at very low impressed voltages. The circled points, here, as for the corresponding curves of the dry wick, represent the voltage and current at which the ionized leaders started. It is particularly important and significant to observe that the currents for these circled points are quite consistently double the corresponding values for the dry wick, thus allowing ample latitude as a factor of safety before leaders and their consequential radio interference develop. The data from these tests and brief notes relative to the associated noise conditions are included in Table II. Likewise, as for the dry wick, no radio noise could be detected from the occurrence of ionization or of visible corona up to those voltages at which the ionized leaders appeared.

These tests on the chemically sharpened bristles definitely confirm the author's early analysis of the basic concepts that with sharp tapering metallic elements initial ionization and glow-corona, alone, do not cause radio interference.

Prior to the various series of tests already described, extensive experiments were performed on similar dissipators in which alternating current was used as the source of power rather than a d-c supply. Here, too, no radio noise occurred in the receiving instruments during the initial ionization and glow-corona phases, but, at the first appearance of leaders, radio noise started promptly and increased greatly for only slight rises of voltage above the threshold value for leader formation.

The conclusion is therefore clear and well established that it is only when sparks occur, such as even the most minute sparks within the ionized leaders, that radio noise from parasitic sources becomes a dominant characteristic and a serious hazard in airplane flight operations.

COMPARATIVE PROPERTIES OF THE DRY WICK, ETCHED NEEDLE, AND METALLIC BRISTLE IONIZER

The ionizing properties of the high-resistance fine cotton fibers, impregnated as they are with their colloidal content of silver salts, are quite different from those by which ionization occurs at sharpened metallic bristles or needle points. The differences lie essentially in two basic categories. One relates to the high threshold voltages in the order of 31 kv required to start ionization at the ends of the ultrafine cotton fibers as compared with the low voltage—less than half the foregoing value—for sharp-pointed metallic electrodes. The other concerns the inhibition of the wick to contribute appreciably to the discharge current through components arising from electric field emission and photoelectric emission within the wick itself. The amazing differences in the threshold voltages at which ionization starts for the dry wick, the needle, and the metallic bristles are shown by the curves of Figure 6.

Because the metallic bristle dissipator employs a plurality of sharp metallic points, it possesses ionizing characteristics approaching closely those of the needle. But, because the electric field converges upon the many bristles of the unit rather than upon a single point, the threshold voltage causing ionization is not quite as low as that of the needle.

The discharge currents for the dry wick, the needle, and the metallic bristles are shown plotted against gap spacings in Figure 7 for an impressed voltage of 60 kv.

It may be seen that the higher current discharge characteristic of the bristle ionizer compensates in part the outstanding advantage of the lower ionization threshold voltage of the needle.

This important feature of superiority of the metallic bristle ionizer is shown by the current ratios in Table III. These two current ratios are plotted against the voltage applied across the gap in Figure 8. At the higher voltages, the "current, ratio *B/W*" approaches a value in the order of 2—showing the metallic bristle ionizer to be two times more effective in its discharge than the dry wick. However, the voltage on an airplane should not be permitted to attain the higher values; and, at the lower voltages, the relative effectiveness of the metallic bristle ionizer greatly increases, as shown by the values of the ratio *B/W* in the order of 4 to 5, or more.

The lower the threshold voltage at which ionization starts for electrostatic dissipators the less likely is radio noise to develop by current discharges from parasitic structural sources such as burrs or other sharp points, located where high potential gradients exist.

Metallic bristle dissipators start their ionization at potential gradients much lower than is possible for even the sharpest burrs.

Once the electrostatic dissipators begin ionizing and the discharge currents become effectively large, the potential of the airplane should decrease rapidly to a value well below that at which parasitic ionization can start.

No radio interference can occur thereafter just so long as the ionizers do not exceed their "quiet discharge" currents—that is, currents beyond which the sparking leaders develop. It is seen by the circumscribing dashed line in Figure 2 that the range of "quiet discharge" current at which ionized leaders appear for the dry wick to cause radio interference at the 4-centimeter gap and longer is of the order of 50 to 75 microamperes. For the metallic bristle ionizers the corresponding range of "quiet discharge" current lies within the values of about 109 to 168 microamperes.

The fact that the total discharge currents for the tufted metallic bristle ionizer is composed of the sum of the relatively small component currents from each of the many contributing bristles is of utmost importance. The current from any individual bristle is exceedingly small and yet radio interference starts when the current from a single bristle reaches that phase of ionization at which ionized leaders form. When this occurs, the total discharge current from the unit is the summation of the currents from all of the contributing bristles. Hence the safe discharge current from and the effectiveness of the tufted bristle ionizer is seen to be greatly superior to any single ionizing element.

The wick, even with its high oscillation suppressor resistance, causes radio interference when ionized leaders develop at its tip. The radio noise occurs in precisely the same manner for it, and fully as intense, as in any electrostatic dissipator during the presence of sparking leaders—despite the claim that the use of a suppressor basically eliminates radio noise. Quite naturally this observation and demonstrated fact raises the fundamental question as to the efficacy of suppressor resistances in electrostatic dissipators and challenges the basic principle underlying the design of the dry wick in which a particularly high-resistance suppressor is utilized and is stated to be an essential feature in eliminating radio interference.

Some thought on the subject would lead one to the inevitable conclusion that the presence of the suppressor resistance within the dry wick could not and, theoretically, should not influence appreciably the initiation of radio noise. The radio interference is caused by radiation from the tiny sparks within the leaders which result from progressive electron and positive ion avalanches, originating near the tip of the ionizer and variously propagating into the gap space. The initiation of these avalanches within the gap space is entirely independent of the presence or absence of the suppressor resistance. The phenomenon by which the cumulative multiplication process forms and propagates leader avalanches depends wholly upon energizing an electron near the tip of the electrode, under the accelerating force of a high potential gradient, to a kinetic energy of sufficient magnitude to ionize by collision whatever molecules of gas it strikes within the ambient air.

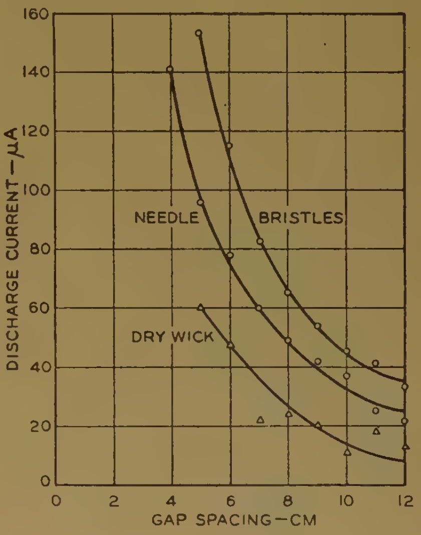


Figure 7. Current discharge characteristics for an applied voltage of 60 kv at various gap spacings, showing their approach to limiting minima for a very long gap

The spark impulses which occur from these ionized leaders within the gap are transmitted the few inches through space to the metallic airfoils and through them into inductive proximity with the radio antennas. The suppressor resistance in no way affects this phase of radiation of spark impulses. In proof of this, the author has transmitted spark impulses from leaders formed within a spark gap, whose radiating ranges in air were not over 10 feet, along a conducting pipe line from the vicinity of the spark gap to distances of 40 to 50 feet without appreciable attenuation—thus showing that the radiation readily is conducted in this manner for relatively long distances along a metallic channel.

If the suppressor resistance should be incorporated into a long configuration of several feet rather than only a few inches—as in the 12-inch wick—in order to isolate the location where the spark impulses originate, and if the radiated impulse energy then is attenuated wholly during its passage through the several feet of intervening air, the radio interference would be reduced to nil. In this unique capacity of removing the ionizing tips of the static dissipators far from the airfoils, as was a feature of earlier attempts at eliminating radio interference, the pseudo-suppressor is being used essentially as an "isolator". However, in damping out whatever fluctuations occur while conducting the discharge current from the airfoils to the ionizing tips, or vice versa, the suppressor then is serving its intended function—except that this service should be wholly unnecessary and a suppressor should not be required in a properly designed electrostatic dissipator.

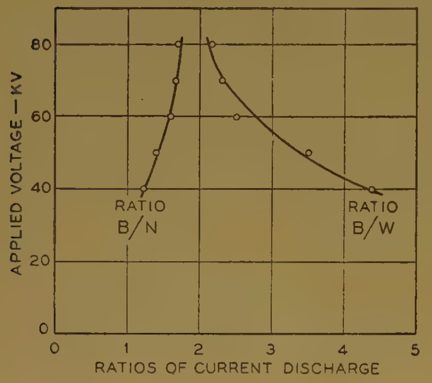


Figure 8. Ratios of the discharge currents for the metallic bristle ionizer B to those of the needle N and the dry wick W with respect to applied gap voltage

Gap spacing 12 centimeters

Sudden variations in the electrification of the airplane do not introduce, in themselves, radio interference. The sudden variations in potential merely change the degree of ionization at the points of the electrodes and thereby increase or decrease the discharge current. So long as the dissipators do not become overloaded to the extent of initiating leaders, radio noise will not be introduced from them even by large variations of electrification of the airplane. However, if the potential on an airplane is not reduced by the static dissipators to such a low value that parasitic sources of ionization are not permitted to radiate, radio interference can and will occur and its intensity will change with variations of the ionizing potential.

Investigators in trying to develop effective static dissipators which were based upon the oscillation suppressor theory, in addition to not having determined that ionization from very sharp metallic points up to the value at which ionized leaders form does not create radio interference, have devoted too little consideration to the imperfections in airplane construction whereby burrs and other sharp points may be more effective and more sensitive ionizers than the alleged dissipators which they have designed and installed. Hence, if potential gradients at the sharp burrs are sufficiently high to develop ionized leaders, even with installed static dissipators of inefficient and inadequate design, radio interference still will persist and the radio noise problem still remains unsolved.

MECHANISMS OF IONIZATION WHICH DIFFERENTIATE WICK AND METALLIC IONIZERS

It has been stated earlier that, when a system of metallic electrodes is electrified to the extent of ionizing air, two general sources of ions contribute to the presence of electric charges within the gap space. One source resides wholly within the ambient gases of the air when these gases ionize, as they do under the influence of sufficiently high potential gradients, first by electron–molecule collisions and secondarily by photon bombardment where the photons originate both from planetary electrons changing to lower energy levels within excited atoms and from ionic recombinations. The other source of ions resides wholly within the metal of the electrode in the form of free electrons. These can be liberated from the metal by endowing them with sufficient energy to overcome or break through the surface potential barrier. The bombardment of the negative electrode by positive ions of the space charge formed by the gaseous ionization within the gap is one mode of accomplishing this; another is that of inducing electrons out of the metal by adequately exciting them at their resonant frequencies through the photoelectric process—where these photons also originate in the gaseous ionization of the gap space. Both of these contributions of electrons increase at a cumulative rate as the voltage is increased and, hence, the presence or absence of these contributions greatly affect the magnitude of the discharge current which flows in response to the higher values of impressed voltage.

In cotton floss with its impregnation of colloidal silver salts, conditions of ionization differ greatly from those at sharp-pointed metallic electrodes. The finely dispersed colloidal particles of silver, which are diffused throughout the cotton fibers, are immersed in a dielectric environment. Because of this, both the intensity and distribu-

Table III. Comparison of Discharge Currents for Each Type of Dissipator

12 Centimeter Gap Spacing

Applied Voltage, Kv	Current in Microamperes			Current Ratios	
	Wick W	Needle N	Bristles B	B/W	B/N
40	2.5	9	11	4.38	1.22
50	7	15	21	3.0	1.40
60	13	21.5	32.5	2.50	1.51
70	20	28	46.5	2.32	1.66
80	28	36	61	2.17	1.70

tion of the electric field are modified from what they would be for a metallic electrode. The electric field intensities at the individual particles of silver are reduced because of the readjustment and diversion of the electric field to the surrounding dielectric substance. Hence, what should be important contributions to the total discharge current, resulting from the liberation of free electrons from the silver particles within the wick itself by electric field emission and photoelectric emission, are actually insignificantly small even at values of impressed voltage approaching those of spark-over.

This characteristic inhibition of the metallic particles within the wick against liberating their free electrons across their surface potential barriers into the interelectrode gap by virtue of ion bombardment and photoelectric effects constitutes one important fundamental disadvantage of the dry wick dissipator in not utilizing the prolific sources of free electrons which exist within a metallic electrode and which become available in increasing numbers from it at the higher potential gradients.

Another basic disadvantage in the use of ionizers as small in diameter as the fibers of the cotton-floss wick, even if they were of highly conductive metallic filaments, results from the disproportionately high potential gradients required to cause them to ionize at the glow-corona stage. The diameters of the cotton fibers range from about 0.06 to 0.02 those of the metallic wires, as used by the author in his tufted metallic bristle unit, and hence the potential gradients at which glow-corona appears on these ultrasmall diameter ionizers as compared with the 0.002 inch wire bristles are in the approximate order of four to seven times higher. This fact explains, in part at least, why the high threshold value of 31 kv is required to initiate measurable ionization for the dry wick.

FEATURES OF THE IDEAL STATIC DISSIPATOR FOR AIRCRAFT

Theoretically the ideal static dissipator should discharge the electrification of an airplane at its first appearance, and instantly, to the degree that no difference of potential with the surrounding space could exist on it. Practically this theoretical ideal is impossible to realize because of the necessary compromise of physical factors which only permit electrically charged points to ionize the ambient air when the impressed potential gradients of the airplane attain their threshold intensities. Hence, the characteristics of the ideal static dissipator to be practical must take cognizance of these physical factors and must incorporate the necessary compromises which are basic to this particular problem.

Therefore, the practical static dissipators for the elimination of radio interference should embody the following salient features:

1. Start ionization at the lowest possible potential gradients.

2. Create copious ionization at relatively low potentials.

Table IV. Comparative Ionization Tests of the Dry Wick and the Tufted Bristle Static Dissipators

Ionizers at Negative and Also Positive Polarities; 3-Centimeter Gap

Negative Polarity		Positive Polarity	
Peak Kv	Ionization in Microamperes	Peak Kv	Ionization in Microamperes
Dry wick			
13.0	0.06	11.3	0.06
21.3	0.10	14.8	0.07
26.7	0.13	20.6	0.10
32.3	0.16	26.6	0.13
38.3	6.0	32.8	0.16
		38.3	0.25
Metallic bristle ionizer			
8.5	0 045	9.5	0.10
12.3	5.6	12.3	1.10
13.7	9.7	15.4	6.00
15.1	13.5	17.0	9.50
17.9	22.4	23.7	25.2
23.3	41.5	29.9	51.6
28.7	72.0	33.6	73.5
31.7	97.5	36.2	85.0
33.7	117.0		
36.7	150.0		

3. Be much more sensitive ionizers than the sharpest burrs occurring on rivets, edges of metal airfoils, and other parts.

4. Discharge rapidly under sudden high rates of rise of impressed potential.

5. Have no need for an oscillation suppressor by virtue of using sharp slender metallic ionizers.

6. Exhibit no appreciable reduction in the ionizing properties of their tips from the presence of moisture, oil, grease, and dirt.

7. Be self-cleaning at the tips by virtue of their ionizing activation and of their hard smooth surfaces.

8. Maintain high ionizing effectiveness even when wet or coated with ice.

9. Maintain the sharpness of their ionizers without appreciable deterioration.

10. Possess structural properties to resist indefinitely the transient forces of air turbulence.

11. Require no maintenance service and expense throughout their life.

12. Possess a life span of years.

13. Be suitable for mounting on the tips of wings, stabilizers, and rudders both in the cross-flow of air as well as in the slip stream.

14. Cause no interference with normal maintenance service on the air-foils, such as periodic cleaning.

15. Be resilient in the slip stream and not interfere in any manner, by accident or otherwise, with the operation of the control surfaces.

16. Lend themselves to decorative color schemes on the edges of the airfoils.

17. Be so inconspicuous and small as not to attract unfavorable attention from passengers and not to detract from the attractive streamlines of the airfoils.

18. Possess low initial cost and be installed readily and inexpensively.

These features have been incorporated successfully into the tufted bristle ionizer. By installing an adequate number of sensitive bristle ionizers at electrically strategic locations, high potential gradients are not per-

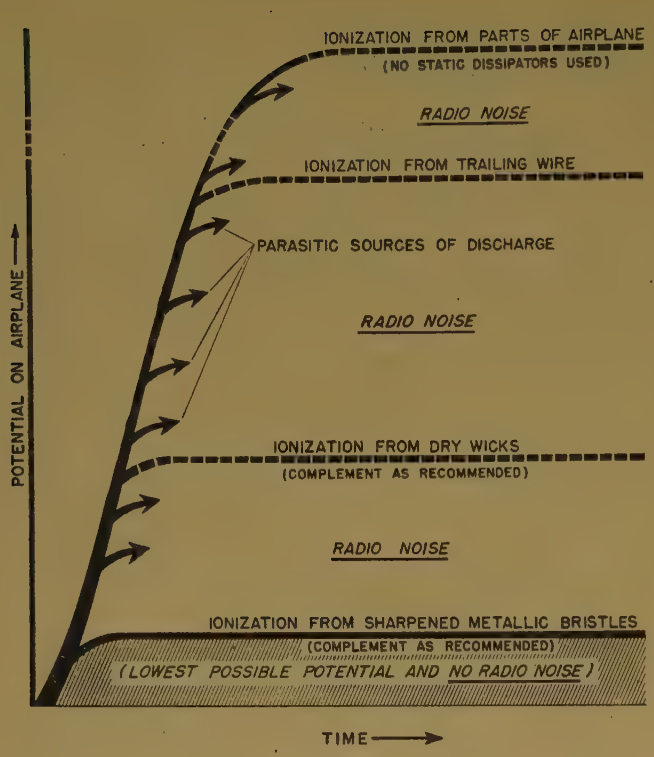


Figure 9. Equilibrium potential levels of discharge by various electrostatic dissipators

Showing parasitic discharges at the higher voltages and why the metallic bristle ionizers eliminate all radio interference by maintaining a potential well below the threshold value for the parasitic sources

mitted to develop on parts of the airplane. Tests of these metallic bristle ionizers on laboratory airplanes to date, under conditions of snow and other forms of precipitation, have demonstrated under actual flight that they neither develop radio noise, per se, nor do they permit it to develop from parasitic sources.

The method of approach to the solution of this electrostatic problem by the author and the relative features of efficacy of the metallic bristle units in comparison with the dry wick and other means of ionization in discharging an electrified airplane and in preventing radio interference from parasitic sources, are portrayed graphically in a striking manner by Figure 9. Without the benefit of any applied static dissipators, the transient potential rise on the airplane may attain the magnitude of a million volts or more, causing the corona discharge finally to equalize the charging rate and establish potential equilibrium. During the corona discharge, burrs and other sharp points and edges of the airplane throughout the areas of high potential gradient are the inherent ionizing agencies. The levels of potential at which the various parasitic discharges begin are illustrated by the heavyweight spur lines radiating from the potential curve and the summation of the individual discharges from these spurious sources is the total discharge current from the airplane. The radio noise under these conditions attains its maximum interference.

If dry wick static dissipators are installed, in their recommended number, the potential of the airplane now will not rise as high as before—a condition shown by a lower labelled line, but they are quite inadequate in their discharging effectiveness to lower the potential to the degree that some burrs and other sharp parts do not ionize to the extent of developing sparking leaders and radio noise.

With tufted bristle ionizers properly installed in adequate number, the potential of the airplane is lowered well below the potential gradients at which even the sharpest burrs can ionize, a condition shown by the lowest line, and in this case no radio interference can or does develop.

Another feature of marked superiority of the tufted bristle ionizers as compared with the dry wick lies in their highly effective discharge when they are operated with positive polarity. This feature is shown by the test data of Table IV. Here, when the dry wick is energized with positive polarity, it is seen to be rendered practically inoperative.

OTHER SOURCES OF ELECTROSTATIC ILLS ON AIRPLANES

The author has investigated a number of fire and explosion hazards from electrostatic causes on airplanes both in flight and on ground. These assume various degrees of importance in flight operations and in maintenance depending upon the nature of the hazard. In order to avoid the costly experiences of fires and explosions within hangars, on the aprons, and at the passenger ramps, the operating personnel should be cognizant of the hazards and trained not only in preventive measures but also in the basic principles underlying the electrostatic causes and controls.

Some of these major problems which particularly need clarification and which are costing operating airlines and the air services of the Armed Forces of the United States large and unnecessary annual expenditures are

1. Accelerated deterioration of airplane engines from electrostatic causes.
2. Refueling hazards from electrostatic generation in gasoline lines.
3. Electrostatic induction hazards to parked airplanes.
4. Electrostatic hazards arising from conventional apron construction.
5. Electrostatic hazards during servicing operations on airplanes.
6. Electrostatic explosion hazards within airplane cabins and other enclosures.

Each of these important topics affects either the safety of personnel or the public or the economic status of the organization. Preventive measures against the ravages of static electricity can be installed and applied so readily that it is unfortunate, indeed, that management takes the costly gamble of ignoring those safeguards, which could be provided at a fraction of the cost of one ruined airplane.

Electronic Frequency Changers for Aircraft

O. E. BOWLUS
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Several main aircraft engine-driven alternators can be operated in parallel by using an electronic frequency changer with each alternator and paralleling the outputs of the changers at the load bus. A mechanical constant-speed drive for each generator is then unnecessary.

AS A RESULT of the considerable increase in the size of military aircraft and the subsequent necessity for larger power-driven equipment, great changes were made in recent years in the requirements for electric power in large airplanes. Because of the considerable weight penalty imposed by the size of the conductors required to carry the d-c power loads, consideration was given to higher voltage systems and also the use of alternating current.

The operation of several alternators to supply the power necessary on large military aircraft presented new problems. Among the requirements to be fulfilled were

1. Parallel operation of alternators into a common load bus.
2. Automatic division of load between alternators.
3. Provision for cutting out a defective unit without disturbing the others.

The first requirement can be met easily provided the alternators are driven at the same rate of speed. However, it was desirable that, in large military aircraft, the generators be driven by the main engines; this introduced a serious problem. Because of the variations in the rotating speed of the airplane engines, parallel operation of the generators was impossible unless one of two methods were adopted:

1. Provide a variable speed mechanical drive between the engine and alternator, with a governor to maintain constant alternator speed.
2. Drive the alternators at variable engine speed and change the variable frequency output from each alternator to a constant frequency for paralleling.

As no satisfactory variable speed drive was available at the time, and because a frequency changing unit, in addition to permitting synchronization of the alternators, also could be designed to meet requirements *2* and *3*, such a unit appeared to offer desirable features for the parallel operation of the alternators.

FREQUENCY CHANGER

The electronic frequency changer is in essence an electronic commutator which accomplishes the conversion of power with a wide range of input frequencies to a constant output frequency.

Functionally, the device has two distinct circuits, a power circuit and a control circuit. The power circuit accomplishes the actual frequency conversion and has associated with it the voltage regulating circuit, the load division circuit, overload protection, and the necessary control circuits for starting the device and applying load. The control circuit establishes the output frequency, provides the necessary phase displacement of control signals to the power circuit to establish a three phase output, and incorporates the necessary circuits for synchronizing two frequency changers.

Average line output voltage is regulated by controlling the excitation of the alternator supplying input power by a carbon pile regulator. Because output frequencies of units operating in parallel are maintained exactly in step by interconnection of the oscillators which determine the output frequency, circulation of reactive current between units is not a problem. Load division is controlled by the relative excitations of the alternators supplying the units.

The generator may be mounted directly on the engine if an adequate pad is available and vibration not too severe, or driven by a power take-off shaft; the frequency changer may be in the nacelle and be connected to the main power lines running through the wing to the fuselage. Other wires may be connected to the necessary meters and control switches at the flight engineer's station.

Electronic frequency changers have been used on public utilities systems for a nonsynchronous tie but for aircraft applications some differences in the control system and the number of power tubes used are desirable. These differences permit operation of any one changer alone and without rotating equipment floating on the line.

TEST UNIT

Experimental work on a pair of 4-kva units of this type was undertaken (the 4-kva size representing the largest unit which was considered economically practical for experimentation).

Two different power circuits were built and tested. Power circuit *1* is in essence three independent single phase frequency changers and is of especial interest if

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Essential substance of paper 47-5, "Parallel Operation of Aircraft Alternators Using Frequency Changers", presented at the AIEE winter meeting, New York, N. Y., January 27-31, 1947, and scheduled for publication in AIEE *TRANSACTIONS*, volume 66, 1947.

O. E. Bowlus and P. T. Nims are both with the Chrysler Corporation, Detroit, Mich.

only single phase output is needed. The circuit is of the parallel inverter type.

Power circuit *2*, Figure 1, uses three center tapped reactors to replace the output transformers and commutating reactors. The necessary capacitors and the voltage regulator circuit are also shown.

CONTROL CIRCUIT

Vacuum tubes have proved to be inherently more stable than gas-filled tubes for this application. Transformer coupling must be used between control circuit and power circuit because the cathodes of the various power tubes cannot remain at the same potential. Some difficulty was experienced in keeping transient voltages set up by the opening of contactors from getting back into the control circuit, causing the two control circuits to drop out of synchronism. Placing small capacitors across the contactor hold-up coils eliminated this trouble. Any change in load on the control circuit such as turning the power circuit on or off on failure of power tubes to commutate has an effect upon the stability of the flip-flop circuit. This effect was minimized by placing a resistance load across the primary winding of each transformer in the flip-flop circuit such that a change in driving power to the grids of the power tubes represents a small change in total load on the flip-flop circuit.

SYNCHRONIZATION

Three separate components of the control circuit must by synchronized with corresponding components in the second control circuit:

1. The single-tube *884* saw-tooth control oscillators are synchronized by feeding a portion of the plate saw-tooth signal from each tube to the grid of the opposite tube. The resulting frequency will be equal to that of the fastest circuit rather than an average of the two.

2. The 3-tube *6J5* switching or counting circuits used to obtain the 120-degree displacement between output phases must be synchronized. By means of an auxiliary tube, a signal is fed from the plate of a *6J5* tube in one circuit to the grid of the corresponding tube in the other circuit. A switch is momentarily closed to obtain synchronization.

3. The 6-tube *6V6GT* flip-flop circuits which control the grids of the *FG-67* power tubes must be synchronized. The six tubes in each circuit are maintained in proper firing sequence by two small capacitors connected between screen of one pair and grid of another pair. To eliminate the possibility of the six tubes in one circuit being 180 degrees out of phase with the other circuit, a small capacitor between a plate in one circuit and a grid in the other brings them in phase by closing a momentary-contact switch.

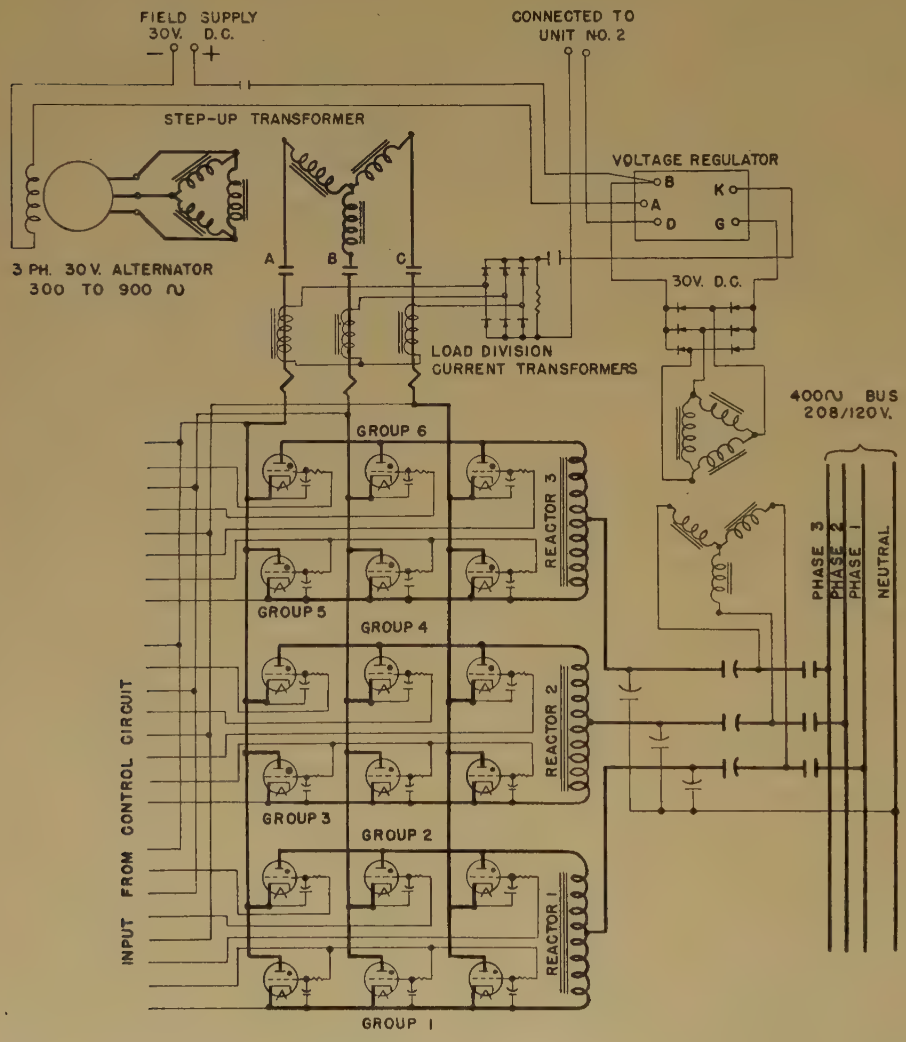

Figure 1. Power circuit 2 suitable for supplying 3-phase constant-frequency power from a 3-phase variable-frequency source

PARALLEL AND SERIES CAPACITORS

The parallel capacitors (line-to-line or line-to-neutral) may be connected either on the tube side or the load side of the three series capacitors which are connected in series with each output line. The purpose of both the parallel and the series capacitors is to assist in the commutation of current between the power tubes. Though the grid of a thyratron tube can be used to prevent or control the instant of start of plate current flow, once the plate current is flowing, other means must be provided to turn off the current. The capacitors provide this means by causing the plate to go negative at the instant the grid is made negative and remain negative for a time sufficient to deionize the tube.

LOAD DIVISION

The first attempt at load division was to place a current transformer in each of the output lines. A voltage proportional to load, obtained from the drop across a resistor in a secondary winding, was applied across a resistor in series with the corresponding phase of the primary of the voltage regulator step-down transformer. All three phases were so connected, the resistors being inserted at the neutral of the Y-connected primary. Wires were connected from the step-down transformer in one changer to the step-down transformer in the other changer to obtain cross-compensation. This system worked well at heavy loads but was not satisfactory at light loads. One changer would tend to drive the other.

Figure 2. Front view of a 4-kva electronic frequency changer

The tendency for one unit to drive the other was overcome by placing the current transformers in the input lines to the changer just after the step-up transformer. The alternating current from the three single-phase current transformers is rectified with a 3-phase rectifier into a resistor, the direct voltage being proportional to input load. Load division and cross-compensation are then accomplished by connecting to a compensating coil in the voltage regulator. See Figure 1.

NEUTRAL FOR 4-WIRE SYSTEM

An artificial neutral must be provided to obtain a 4-wire 3-phase system.

Y-connected capacitors were used, because inductors, if used, present an inductive load to the changer thereby requiring additional capacitive compensation. By connecting the parallel capacitors line-neutral rather than line-line, no additional capacitors are required for power factor correction. The capacitors, in addition to providing the same degree of stability of the neutral, do not carry a weight penalty.

At best, the artificial neutral will handle only a small single-phase load without unbalancing both line-line and line-neutral voltages.

TEST RESULTS

Two units were built and operated satisfactorily in parallel. Each unit has its individual control circuit and the control circuits were synchronized for parallel operation by pushing a button. Load division was accomplished very easily.

Heavy resistance loads could be handled under all conditions. Inductive loads larger than approximately 1,250 volt-amperes per unit required power factor correction for satisfactory operation. Power factor correction can be accomplished by adding small capacitors across the inductive load.

A single unit or both in parallel would start and operate a 3-horsepower induction motor provided a large resistive load was already on the line or applied with the motor. One-quarter horsepower motors operated satisfactorily without additional resistive load and without power factor correction. Large motors required power factor correction and the presence of sufficient resistive load to stabilize operation.

While the test circuit had only one-tenth the volt-ampere capacity that probably could be used in an airplane, some of the test results are of interest in indicating the trend of the performance. One such test was variation of alternator speed; input frequency was varied from 300 to 900 cycles with negligible effects on output frequency, voltage, and watts. Load division data were taken with one unit operating at a 450-cycle input frequency and the other unit at 300, 500, 700, and 900 cycles successively. Frequency of incoming power seemed to have no noticeable reflection on the ability of the units to share load; however, the load division did display a tendency to drift at times as the voltage regulators heated up.

THE POWER TUBES

When the input frequency becomes equal to the output frequency, only 12 of the 18 power tubes transmit power. This means that the tube size has to be chosen with this in mind or else the generator drive ratio chosen with respect to the operating speed range of the engine to minimize operation at these input frequencies. At other speeds, the division of load between tubes is good and substantially independent of individual tube characteristics. In fact, any one power tube can be removed from the circuit bodily with only minor effects on the output. This characteristic argues well for the reliability of the circuit.

As the experimental unit used a step-up transformer to

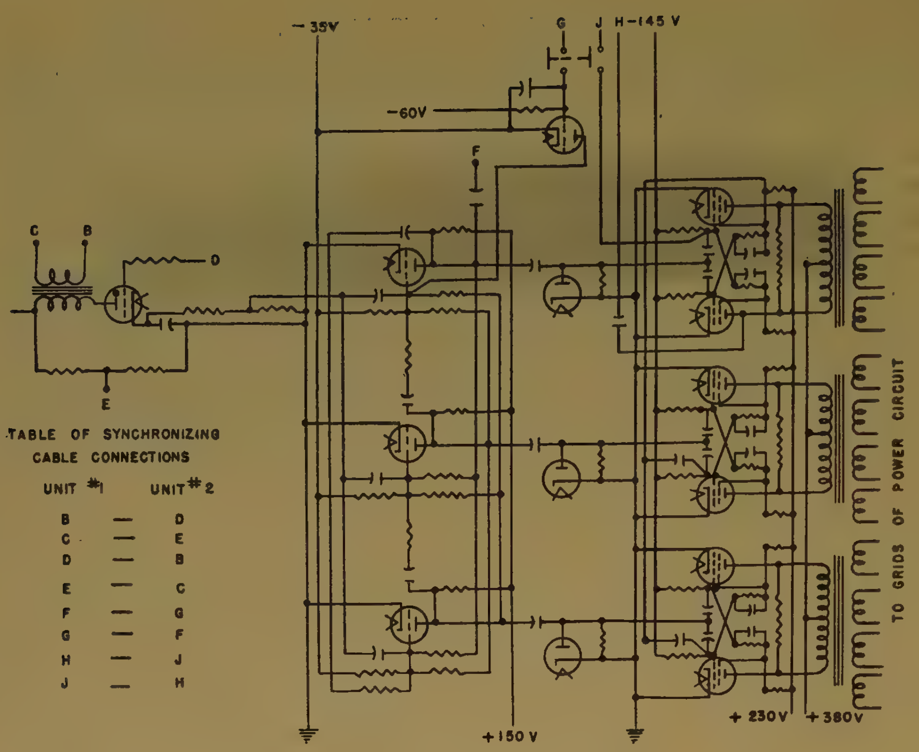

TABLE OF SYNCHRONIZING CABLE CONNECTIONS

UNIT #1		UNIT #2
B	—	D
C	—	E
D	—	B
E	—	C
F	—	G
G	—	F
H	—	J
J	—	H

Figure 3. Circuit diagram of one control unit

Synchronizing connections are indicated for parallel operation with a second unit. Output connections are shown for operation with the power circuit of Figure 1

raise the alternator voltage to the necessary value and also as the filament and control power were supplied from a separate source, the most useful efficiency figure is the ratio (output watts)/(transformer secondary watts+filament watts+control circuit watts). This figure most nearly reflects actual operating conditions. This full load efficiency of power circuit *2* with resistive load is about 68 per cent. Loads of lower power factor seem to make only small changes in these values. This is probably due to the effect of the large fixed loss, 410 watts for filaments, and 210 watts for control or a total of 15 per cent of the rated output.

Wave form of the output varies slightly with load. Figure 4 shows the wave form of one phase of the 400-cycle output under three operating conditions and also indicates the voltage applied to the grid of one of the tubes.

POSSIBLE FUTURE DEVELOPMENT

The test circuit was built as a scaled-down model of a 40-kva unit. A full size frequency changer presumably would be operated directly from an alternator designed for the purpose and no step-up transformer would be required. Also an auxiliary alternator probably would be used to supply filament heating power and the various voltages required for the control circuit. Further savings in tube size and weight of some components might be achieved by using a higher voltage (and hence reduced current) in the power tube circuits. This would be more convenient using power circuit *1* as it has provision for stepping down the output voltage to the standard 208 volts.

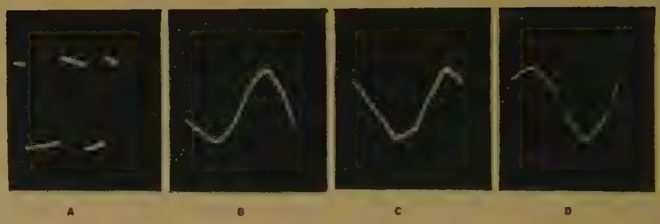

Figure 4. Oscillograms of output wave form

A—Square wave output voltage from control unit. This voltage is applied to the grids of the power tubes
B—400-cycle output voltage at no load
C—400-cycle output voltage at full load, unity power factor
D—400-cycle output voltage with load of 3-horsepower motor plus 3,000-watt resistive load. Three 4-microfarad capacitors are connected line-to-line to correct for the inductive reactance of the motor

For some commercial aircraft with large single phase loads, such as lighting, radio, and cooking, it might be advantageous to consider a complete single phase system using capacitor-type motors. For use with an electronic frequency changer, this would give a relatively high power factor load suited to a 6-tube changer of the type of circuit *1*. In view of the simplicity of the power and control circuits this is an attractive possibility. While single phase loading of a conventional generator is not desirable, the interposition of a frequency changer distributes this single phase load equally among the three phases of the generator, reducing the weight penalty to be expected for a single phase system. There is also some saving in cable weight because of the lesser amount of insulation required in a single wire ground return system.

Single-Pole Relaying and Reclosing on a High-Voltage System

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The isolation of only one phase wire in a single-phase-to-ground fault enables the use of longer reclosing times without endangering system stability. Several years of operating experience results in a favorable comparison between single- and 3-pole reclosing.

THE great advantages to be obtained from the use of ultrahigh speed reclosing on large capacity power transmission lines have been appreciated for about 15 years. Until five years ago, however, this high speed reclosing was limited to simultaneous multi- or 3-pole reclosing. On March 13, 1941, a revolutionary installation of single-phase or so-called single-pole reclosing was placed in service on a 50-mile single-circuit 132-kv line between the Lenore substation at Indianapolis, Ind., and the New Castle substation at New Castle, Ind. This type of reclosing differs from the formerly mentioned 3-pole reclosing in that only the faulted phase is tripped and reclosed simultaneously at both terminals of the transmission line in event of a single phase to ground fault on the line. During the short interval of time the faulted phase is open, either parallel transmission line paths or the ground itself will assume the load current of the interrupted phase.

The original installation of single-pole reclosing was made on the basis that greater system stability would be obtained from this method of switching than from 3-pole switching. The transmission line on which this protection was first applied acted as the major tie between the Chicago and northern Indiana systems and the Cincinnati, Louisville, and Tennessee Valley Authority southern systems, and the proper maintenance of stability between these systems during fault conditions was of prime importance to proper system operation of all parties in the interconnected system. As the system developed, five additional 132-kv transmission lines were constructed (Figure 1) and it was believed that the advantages to be derived from the use of single-pole reclosing greatly outweighed those to be secured from 3-pole reclosing, hence single-pole reclosing was installed on all these later transmission line developments. Four of the five lines are wood-pole-constructed single-circuit lines.

The choice of the method and speed of reclosing may be governed mainly by the consideration of the events which take place during the de-energization or "dead" time of the line in question. The final choice as to speed of reclosing is often a compromise between the maximum reclosing time that may be tolerated when considering possible phase-angle drift of the two opposite terminals from the standpoint of a system stability upon reclosure and the minimum reclosing time that will allow deionization of the gases at the point of fault and prevent too many fault arc restrikes.

Single-pole switching results in much less voltage and power flow disturbance than is caused by multipole switching because of the fact that synchronizing power flows over the remaining two phases left in service. The drift in phase angle between the two terminals of a line thus equipped is retarded, permitting phase de-energization times in the order of 100 per cent over the time normally allowed for 3-pole switching.

PROTECTIVE RELAYS

The relay installation at each of the ten single-pole line terminals consists of the standard power line carrier pilot relay protection with the addition of a "phase-selector" relay (Figure 2) which recognizes the faulted phase and causes it to trip individually for a single-phase-to-ground fault. The phase-selector relay uses negative sequence current and zero sequence current. The negative sequence current is obtained from a negative sequence filter circuit. The development of the vector quantities of these two shows that it is possible for only one phase element of the phase selector relay to close its contacts on a single-phase-to-ground fault, the other two elements being actuated in the nonoperating direction. On any type of fault other than one which involves one phase and ground, all three poles are tripped. In the latter case, all three poles reclose high-speed simultaneously.

The additional maintenance required for the single-pole relay scheme is only slightly greater than for the standard carrier pilot relay scheme used for 3-pole tripping. The component parts which have been added to the standard scheme are only modifications of stand-

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Essential substance of paper 47-67, "Experience With Single-Pole Relaying and Reclosing on a Large 132-Kv System," presented at the AIEE winter meeting, New York, N. Y., January 27-31, 1947, and scheduled for publication in AIEE *TRANSACTIONS*, volume 66, 1947.

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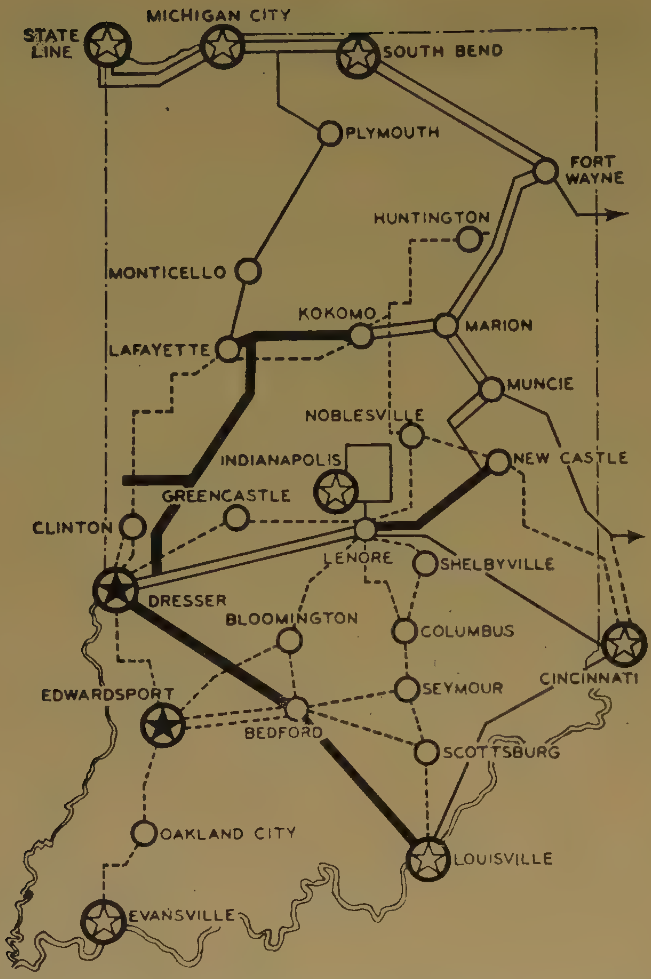

Figure 1. Major high-voltage interconnected lines of the Public Service Company of Indiana, Inc., and neighboring systems

━━━ *The 132-kv lines using single-pole reclosing*
──── *Other 132-kv lines*
– – – *Other high-voltage lines*

ard relay elements, hence their testing is relatively simple and can be performed with the usual test equipment.

The physical layout of the relay panels for two circuits at the Lafayette, Ind., substation is illustrated in Figure 3.

OIL CIRCUIT BREAKERS

The oil circuit breakers located at the terminals of the single-pole operated lines are standard 35-cycle circuit breakers and all but three of them are pneumatically operated. Each pole is equipped with a standard circuit breaker operating mechanism with a central air compressor for the three mechanisms. A typical installation of the single-pole breaker is shown in Figure 4.

OPERATING EXPERIENCE

Operating information on all five 132-kv lines now equipped with single-pole tripping and reclosing for the total number of years the equipment has been in service is summarized below:

Total number of operations due to fault	59
Number of operations under temporary fault conditions	54
Number of temporary single-phase-to-ground faults	42
Number of successful single-pole reclosing operations	38
Number of unsuccessful single-pole reclosing operations	7
Number of temporary multiphase faults	12
Number of successful 3-pole reclosing operations	3
Number of unsuccessful 3-pole reclosing operations	4
Number of permanent faults	5

Of the seven unsuccessful single-pole reclosing operations, three occurred at times when the line was permanently faulted and four occurred due to restrike of the fault arc.

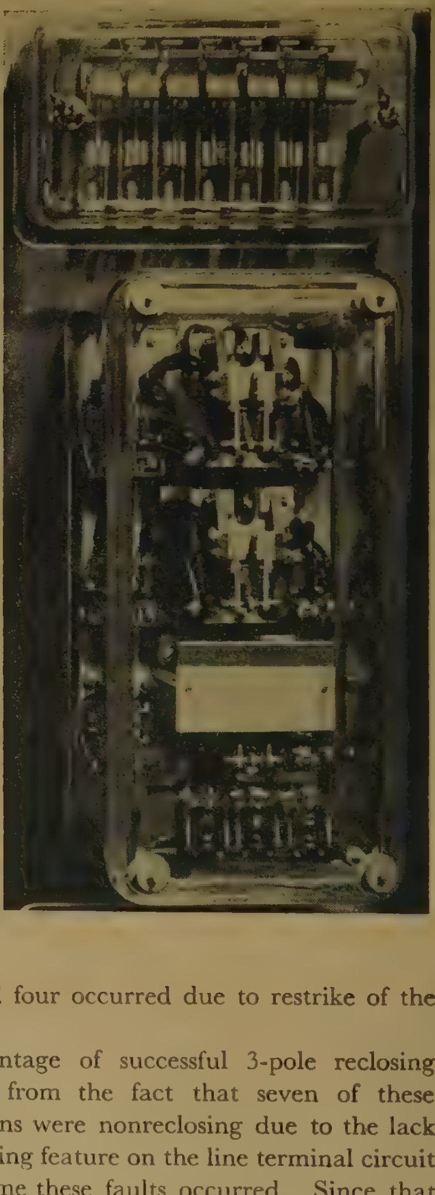

Figure 2. A phase selector relay

The low percentage of successful 3-pole reclosing operations results from the fact that seven of these multipole operations were nonreclosing due to the lack of the 3-pole reclosing feature on the line terminal circuit breakers at the time these faults occurred. Since that time, 3-pole reclosing has been incorporated in the control of the circuit breakers at these terminals.

Two of the four unsuccessful 3-pole reclosing operations were caused by restrike of the arc after the line was reclosed high-speed following the original fault. The remaining two "lock-out" operations were caused by a permanent fault existing on the line.

The operating data do not report experience previous to 1944. Actually there were four operations on this line during the three years not reported. The record of these operations is omitted. Each was incorrect because of electrically and mechanically defective equipment in the relay scheme and the breaker control wiring, hence their inclusion in this article would serve only to cloud the real intent and purpose of the analysis which is made of the operation of the equipment.

ANALYSIS OF THE OPERATING DATA

The largest number of operations resulting from flashover occurred on the Kokomo–Lafayette 132-kv line which purposely was not equipped with a static or ground wire. The operational record of this line might be considered separately from the other four lines involved because it served as an accelerated test line. All 45 faults on this line were of a temporary nature and 82.3 per cent of the faults occurring involved only one phase and ground. Of these temporary 37 faults, 89.2 per cent were successfully cleared and reclosed high-speed, single-pole. This figure well indicates the advantages to be realized by the use of single-pole reclosing and conclusively demonstrates its effectiveness. On two separate occasions, oscillograms taken at the time of operation of this line under fault conditions have indicated that a fault on one phase was cleared and reclosed to be immediately followed 10 cycles later by a fault on another phase, which in turn tripped and reclosed successfully. If 3-pole tripping and reclosing had been employed on this line, it is very doubtful if a successful reclosing operation on such a fault would have been experienced. Only one case of

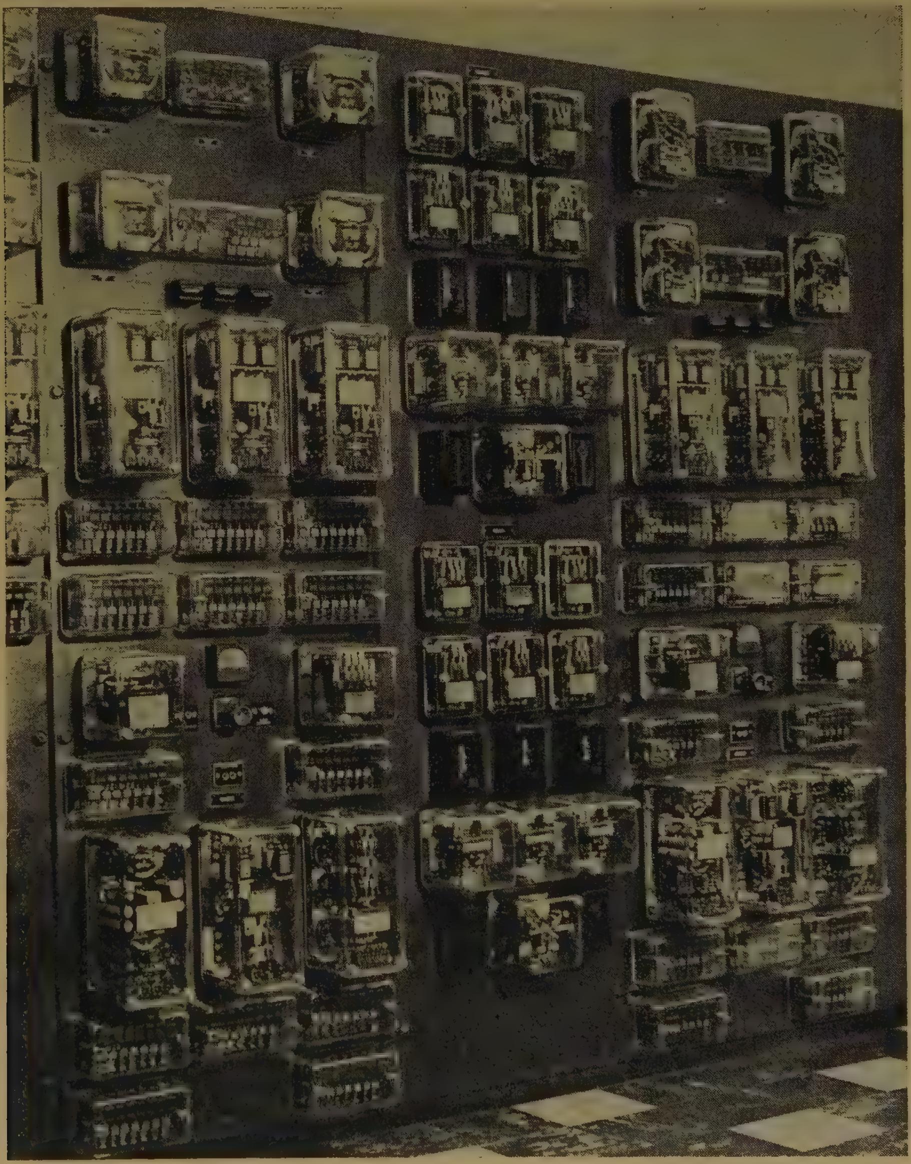

Figure 3. A panel arrangement of carrier pilot relays at Lafayette, Ind.

The phase selector relay is at the lower right. The reclosing relay panel for two circuits appears in the center

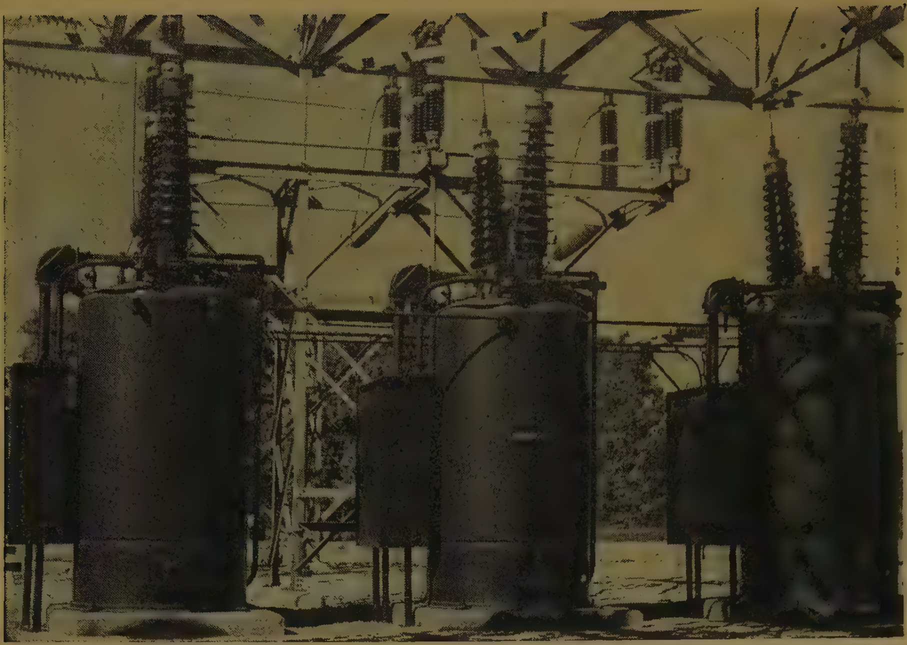

Figure 4. The 132-kv single-pole reclosing circuit breakers at Bedford, Ind.

conductor burning has been observed on the line, and this particular case was not of such severity to cause the line to be removed from service for repair except at a convenient time. Insulator damage due to flashovers is no more severe on this line than on a line protected by static wire and, in the majority of cases, a patrol of the line after an operation reveals absolutely no damage resulting from its momentarily faulted condition.

The average loads carried on each of the five lines involved in this study is in the order of 25,000 kw. However, a number of these operations occurred when the lines were carrying approximately 40,000 kw. Under no operation has system instability been noted. The system voltage disturbance at the time of single-pole action is extremely light and is scarcely discernible even at the terminal stations involved.

Some fear was expressed at the time of the introduction of the single-pole method of operation of transmission lines that the tripping of one phase would cause inductive interference on parallel communication circuits or would bring about "ground" relay co-ordination problems on other transmission circuits which terminate at the same station where the single-pole operated breakers were located. Concern was also expressed that the capacity coupling between the two energized phases and the de-energized phase during a single-pole fault clearing operation would tend to maintain the fault arc long enough that successful reclosing of the isolated phase could not be accomplished. There has been no evidence that such conditions exist in actual operation.

SUMMARY AND CONCLUSIONS

During the past three years, invaluable operating experience has been accumulated in the use of single-pole high-speed reclosing of 132-kv transmission lines on a large interconnected power system. From the data obtained, the following conclusions may be drawn:

1. Of all faults caused by flashover on 331 miles of 132-kv line, incorporating five separate line sections on the system under study, 76.3 per cent involved only one phase and ground.

2. Successful single-pole tripping and reclosing was recorded in 84.4 per cent of all cases of single-phase-to-ground faults.

3. No evidence has been produced for line distances up to 100 miles that indicates that the fault arc is maintained on one phase by its capacity coupling to other phases during single-pole operation.

4. No evidence of system instability has been observed during or immediately following a single-pole reclosing operation even with large amounts of power flowing over the faulted line.

5. Use of single-pole reclosing for single-line-to-ground faults permits longer de-energization periods with greater system stability than does 3-pole reclosing, thereby allowing less chance of restrike.

6. Very little system voltage or power flow disturbances have been noted during single-pole tripping and reclosing operations.

7. No difficulty was experienced with communication circuit inductive interference or ground relay co-ordination on other adjoining transmission line circuits due to single-pole operation.

8. The relaying equipment involved in "faulted phase" selection is simple and reliable and requires no special maintenance. The additional equipment required to operate single-pole instead of 3-pole reclosing on line terminals requires only slightly more maintenance than does the conventional equipment.

9. Single-pole reclosing for this system has all the advantages that are to be realized by the use of 3-pole reclosing and possesses a number of advantages that are not enjoyed by the latter scheme.

10. It is felt that further data which will be accumulated in succeeding years will prove conclusively that single-pole relaying and reclosing has taken its just place in modern power system equipment. Further application of single-pole reclosing is planned on at least three 132-kv lines now proposed for construction on the Public Service Company of Indiana, Inc., system.

Proposed Frequency Band Designations

In answer to increasing demand for a system of designating electrical frequency bands, a joint technical committee on standard frequency bands and designations has considered a number of methods of which the most desirable seems to be a "decade frequency system" based on powers of ten. This article describing the decade frequency system was prepared by the committee primarily for the purpose of obtaining comments and suggestions.

THERE is an increasing demand for a system of designating electrical frequency bands from distribution frequencies up to the very highest ranges obtainable for radar applications. It is desired that these designations shall be definite and easily remembered. The subcommittee on standards of the AIEE electronics committee has given this matter some consideration and has obtained suggestions from a number of experts. More recently a joint technical committee on standard frequency bands and designations considered this matter further. It consisted of representatives of the American Standards Association committee C-68, and AIEE committees on instruments and measurements, communication, and electronics. The system which seems to meet the widest favor is one originally suggested to the committee by Professor H. M. Turner. It is a "decade frequency system" based on the powers of ten, as follows:

Band Designations	**Frequency Limits (Cycles Per Second)**
0	$0-10$
1	$10-10^{2}$
2	$10^{2}-10^{3}$
3	$10^{3}-10^{4}$
4	$10^{4}-10^{5}$
5	$10^{5}-10^{6}$
6	$10^{6}-10^{7}$
7	$10^{7}-10^{8}$
8	$10^{8}-10^{9}$
9	$10^{9}-10^{10}$
10	$10^{10}-10^{11}$
11	$10^{11}-10^{12}$

It will be noted that the band designation is the exponent of 10 corresponding to the lower limit of the band under consideration; namely, the band designation is the characteristic of the logarithm to the base 10 of all numbers within the band.

Other frequency band systems have been proposed, particularly one adopted by the Institute of Radio Engineers* in which the limits of each band are some multiple of three and the range of each is some multiple of ten cycles per second. These frequency limits correspond to a decade system of wave lengths, having wave length limits which are multiples of ten. This really is a wave length system disguised as a frequency system. The band designations are arbitrary and have to be remembered, which is not the case with the designations in the foregoing table; also, the multiple of three limits are objectionable to many people, particularly in the lower frequency ranges.

Some individuals, whose interest does not include the entire frequency spectrum used by engineers, favor a wave length designation, but a complete system cannot be worked out on this basis as all the lower frequency wave lengths have no commercial significance. Moreover, even at the very highest frequencies obtainable, frequencies in general have more significance to the radio engineer than do wave lengths.

An adjective designation of bands, such as ultrahigh frequency, is undesirable, because the limits are hard to remember and change as the art progresses. What was ultrahigh frequency in the laboratory a few years ago, is now commonplace in engineering practice. The adjectives are relative and do not have the same meaning to workers in different phases of electrical engineering. Even if certain groups of engineers find it convenient to use such general range designations as, for instance, the audio range, the centimeter range, or the ultrahigh frequency range, it seems undesirable to give the designations the status of a standard because of the afore-mentioned defects. The relative ease in making measurements of frequency and the high precision obtained as compared with that of wave length is a powerful argument in favor of frequency as a standard.

The committee urges that the decade system proposed in this article be adopted as a national standard. Comments are invited. They should be addressed to the Joint Technical Committee on Standard Frequency Bands and Designations, at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Full text of an article prepared by the joint technical committee on standard frequency bands and designations which consists of the following personnel: *Chairman*, **Thomas Spooner** (F '29) Westinghouse Electric Corporation, East Pittsburgh, Pa., representative of the AIEE committee on electronics; **C. T. Burke** (M '33) General Radio Company, Cambridge, Mass., representative of the AIEE committee on instruments and measurements; **G. B. Ransom** (M '35) American Telephone and Telegraph Company, New York, N. Y., representative of the AIEE committee on communication; and **F. B. Silsbee** (F '42) National Bureau of Standards, Washington, D. C., representative of the American Standards Association sectional committee C-68.

* *Proceedings*, Institute of Radio Engineers (New York, N. Y.), August 1945, page 48.

Wood Structure Burning by Leakage Currents

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Although the number of pole fires is small relative to the total number of circuit-pole-years, the resulting damage and service interruption make their prevention of prime importance.

THE interruption of service and the damage to equipment caused by the burning of wood structures by leakage currents is of prime importance because the majority of the medium voltage lines on the North American continent are constructed on wood poles. In some localities infrequent fires are only an incidental nuisance; in others prolonged service outages may be caused by frequent fires that destroy the crossarms and poles.

Pole or structure fires may be caused by power-frequency leakage currents which flow over the surface of contaminated insulators. Usually pole fires are preceded by a prolonged dry period in which the wood members dry out. During this dry period contamination accumulates on the insulator surface and reduces the surface leakage resistance. A fog, misty rain, or snow will reduce the leakage resistance of the insulators still further. Resulting fires may become evident shortly after the precipitation, or they may not break out for some time. Figure 1 shows the two general types of burns.

The magnitude of leakage currents is controlled principally by the sum of the total resistance of the wood and the surface leakage resistance of the insulator which comprise a series circuit. Pocket burns, which are more likely to necessitate replacement of the wood members than tree burns, are particularly likely to occur if only a small portion of the pole is dry. (A light wind will cause such selective damping by creating dry pole or insulator "shadows" on the damp wood surfaces.) The resulting high resistance of the shadow area in series with a relatively low leakage resistance causes a concentration of the voltage drop across the dry area. If the dry zone is sufficiently short electrical breakdown occurs across the dry zone.

Voltage concentration across high resistance sections may be avoided if a low resistance shunt is placed in

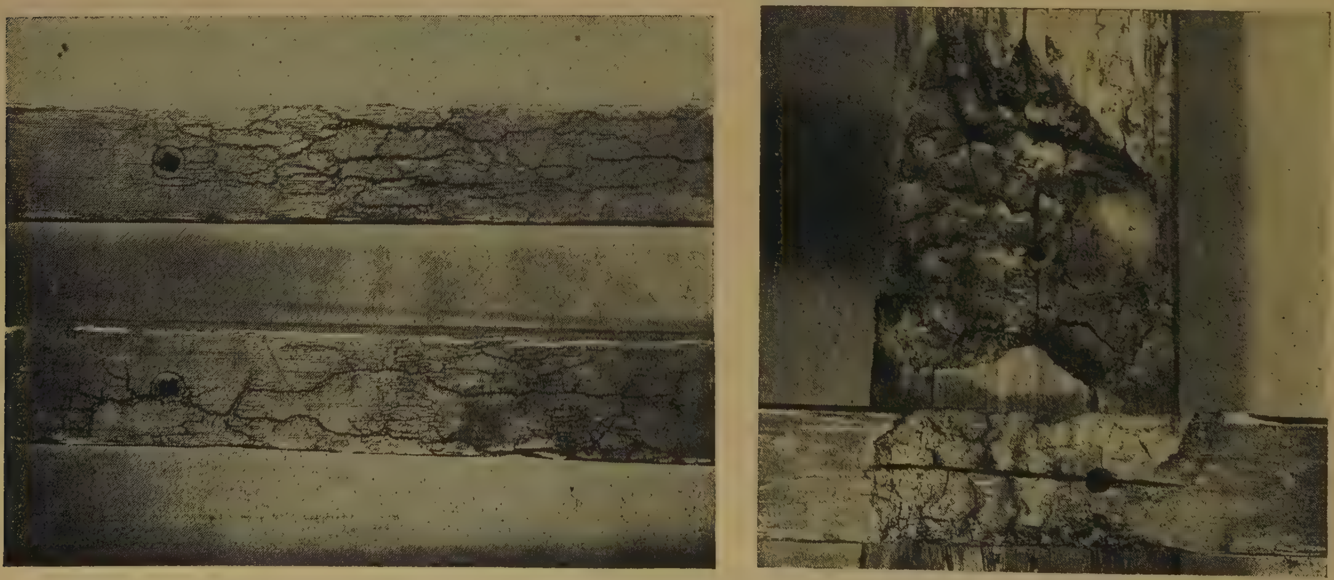

Figure 1. The two general types of burn damage as occured on service installations

A—Tree burning, so named because of the tree-like appearance of the burn pattern, is more common than pocket burning but usually replacement of members is unnecessary

B—Pocket burning extends into the body of the members and often requires their replacement

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Essential substance of paper 47-49, "Burning of Wood Structures by Leakage Currents," presented at the AIEE winter meeting, New York, N. Y., January 27-31, 1947, and scheduled for publication in AIEE *TRANSACTIONS*, volume 66, 1947

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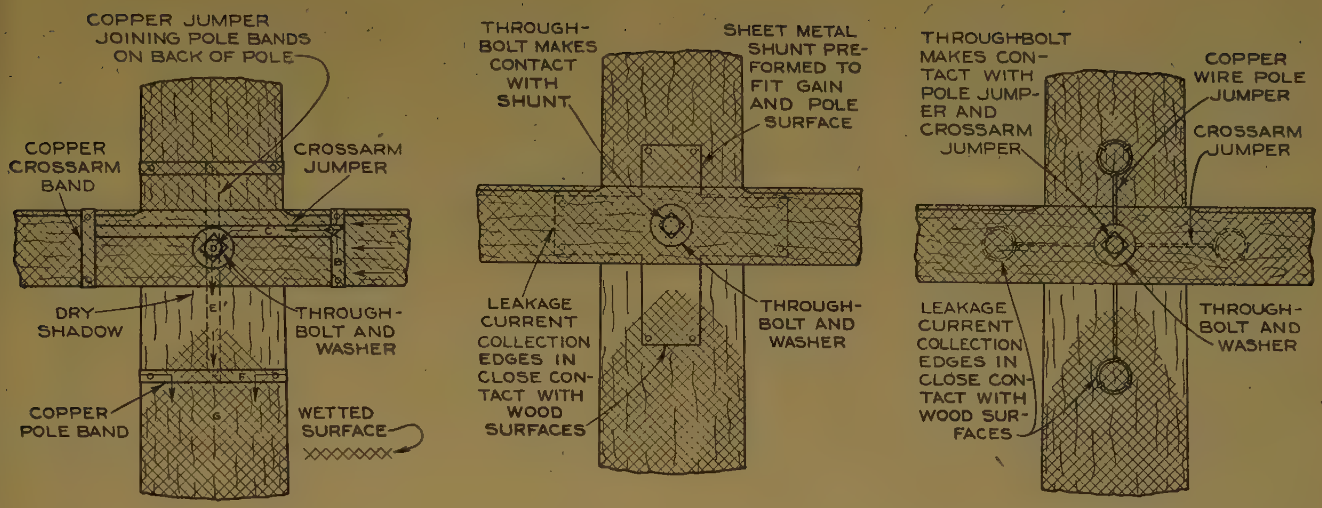

COPPER JUMPER JOINING POLE BANDS ON BACK OF POLE
COPPER CROSSARM BAND
CROSSARM JUMPER
DRY SHADOW
THROUGH-BOLT AND WASHER
COPPER POLE BAND
WETTED SURFACE
THROUGH-BOLT MAKES CONTACT WITH SHUNT
SHEET METAL SHUNT PREFORMED TO FIT GAIN AND POLE SURFACE
LEAKAGE CURRENT COLLECTION EDGES IN CLOSE CONTACT WITH WOOD SURFACES
THROUGH-BOLT AND WASHER
THROUGH-BOLT MAKES CONTACT WITH POLE JUMPER AND CROSSARM JUMPER
COPPER WIRE POLE JUMPER
CROSSARM JUMPER
LEAKAGE CURRENT COLLECTION EDGES IN CLOSE CONTACT WITH WOOD SURFACES
THROUGH-BOLT AND WASHER

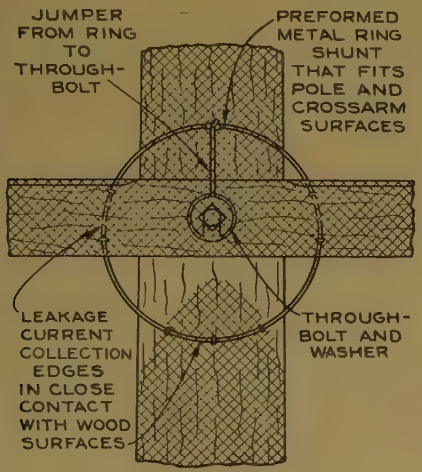

JUMPER FROM RING TO THROUGH-BOLT
PREFORMED METAL RING SHUNT THAT FITS POLE AND CROSSARM SURFACES
LEAKAGE CURRENT COLLECTION EDGES IN CLOSE CONTACT WITH WOOD SURFACES
THROUGH-BOLT AND WASHER

Figure 2. Four shunting arrangements to prevent pocket burns

parallel with them. Figure 2 shows four possible shunting arrangements which were designed after laboratory tests were conducted on approximately 200 specimens. The leakage current collecting edges of the devices must be located outside of all wind shadows of either crossarm or pole and be terminated snugly against the wetted surfaces of the wood.

Pocket burns have not occurred within the shunted areas during laboratory tests. However, shunting devices possess certain disadvantages:

1. They may reduce in a small degree the impulse insulation contributed by the wood structure.
2. The elimination of high resistance areas may tend to increase the magnitude of leakage current as this magnitude is controlled partially by the wood structure resistance.
3. If improperly designed and applied, the shunting devices may cause an aggravated tree burning condition at the current collection edges of the shunting electrodes.
4. The shunts, being metallic, are subject to corrosion and therefore the life of the device should be questioned in relation to the structure it is protecting.

Experience gained from actual installations will be required to evaluate the relative merits and demerits of these devices.

A second approach to the elimination of a voltage

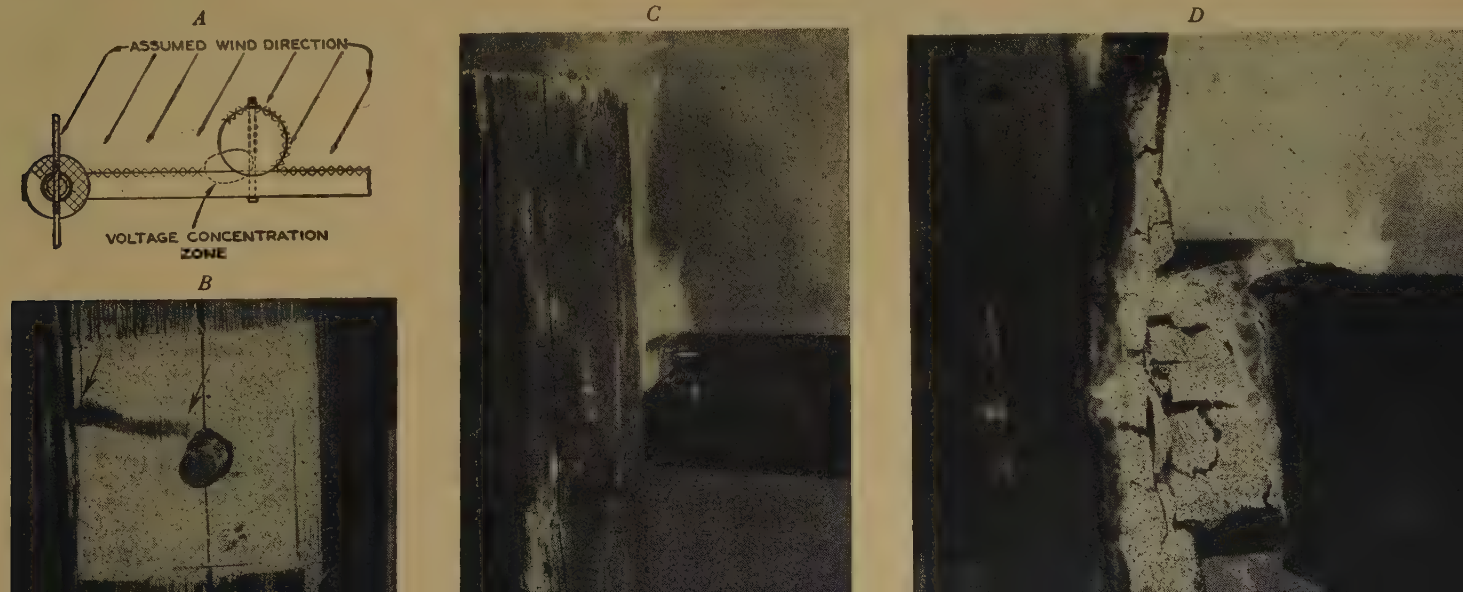
Figure 3. A representative laboratory test resulting in pocket burning

A—Diagram of selective damping of pole and crossarm surfaces

B—Electrical breakdown took place between the through-bolt and the edge of the wetted crossarm surface. Note the resulting carbonized path across the pole gain. There was a mating carbonized path on the crossarm surface

C—Encouraged by the breeze, open flames appeared in about ten minutes

D—A pocket burn developed on the pole and crossarm



concentration zone is through the use of wood treatments which would increase dry wood conductivity. Various other forms of remedial devices undoubtedly will suggest themselves to the practical operator. The final forms will be dictated by cost and expected life.

LABORATORY TESTS

To duplicate but accelerate actual burn damage a continuous power-frequency leakage current of ten milliamperes was used. The high insulator leakage resistance was represented by an impedance inserted in series between the test transformer and the wood specimen.

Precipitation was simulated by a finely divided mist applied from an air-operated spray gun, and wind direction by a fan.

Equipotential line mapping tests were made which supported the hypothesis that voltage drop is concentrated across the dry areas. Figure 3 illustrates a typical test.

Electrification of the 2-for-1 Twister

E. C. GWALTNEY   H. J. BURNHAM

The 2-for 1 twister produces higher quality yarn in about half the time and with a third the power required by conventional machines. The use of electric machinery reduces the number of rejections of finished fabrics necessary because of dirty yarn and increases the uniformity of twist in the yarn. Power consumption and quality of product are independent of the size of the supply package and the amount of yarn on the take-up spool.

BOTH natural and synthetic fibers must be twisted into yarn before they can be woven into fabric. In conventional twisting the yarn is either fed through a pair of rolls and twisted as it revolves around and is wound on a rotating package or the yarn is twisted as it is pulled from a rotating supply package and is wound on a take-up spool. The amount of twist is measured in turns per inch and is the ratio of rotation of the spindle to the linear speed of the yarn.

The possibility of revolving the yarn being twisted around a stationary supply package and obtaining two turns of twist for every revolution of the spindle has been known for years. Figure 1 shows that one turn of twist is obtained between the stationary package and the rotating flyer, which is carried by the spindle, and a second turn is obtained between the flyer and the take-up spool which draws the yarn from the stationary package at a fixed linear speed.

Although it is planned ultimately to apply the 2-for-1 principle to all forms of twisting, its use now is confined to the twisting of fine denier rayon and nylon for use in women's underwear, hosiery, dress goods, and the like which require from 25 to 50 turns of twist per inch.

A substantial saving in power consumption results from the use of a stationary package. Furthermore, the power consumption is independent of whether the package is full or empty. Yarn tensions are constant regardless of any variation in the supply package and can be held to within plus or minus five per cent. (With conventional twisting yarn tensions may vary more than 100 per cent, although a reasonably constant tension is essential for high quality.)

ELECTRIC EQUIPMENT

There must be a free path for the yarn and flyer around the package carrier. To accomplish this, the rotating spindle supports the package carrier on two ball bearings. The spindle rotates within the stationary package carrier which is kept from revolving by two alnico magnets in the bottom of the package carrier and two magnets mounted on the spindle support. In event of failure of one of the bearings, the package carrier and package would start to revolve at spindle speed. To prevent this one of the holding magnets is mounted in a "trap door" which swings open by gravity when the magnet is not held up by its matching magnet in the bottom of the package carrier. Also, the drop magnet is given a push when a like pole passes it. A movement of only five degrees of the trap door releases a spring loaded brake which stops the spindle. Simultaneously, the driving force is removed from the spindle.

Essential substance of paper 47-35, "Electric Equipment for 2-for-1 Twister," presented at the AIEE winter meeting, New York, N. Y., January 27–31, 1947, and at the AIEE North Eastern District meeting, Worcester, Mass., April 23–25, 1947, and scheduled for publication in AIEE *TRANSACTIONS*, volume 66, 1947.

E. C. Gwaltney is director of research and **H. J. Burnham** is test engineer with the Saco-Lowell Shops, Biddleford, Maine.

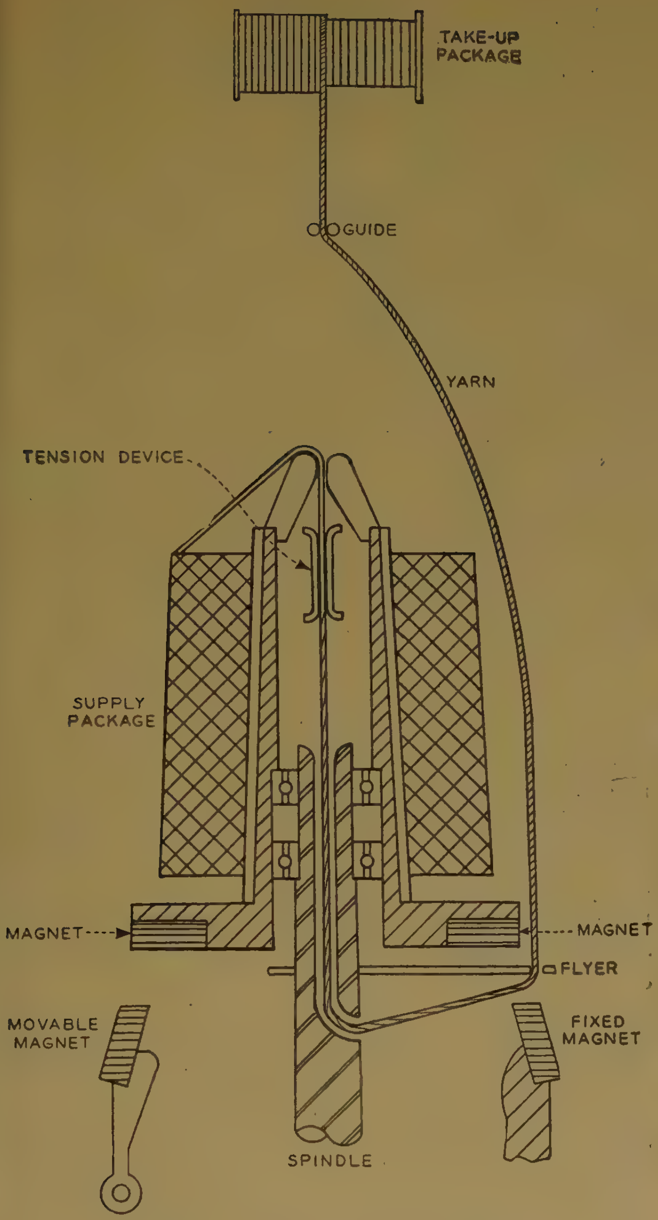


Figure 1. Cross section of the spindle

Spindle Drive Power. The practical operation of the 2-for-1 twister requires that the spindles rotate at approximately 12,000 rpm, and that the yarn take-up be driven at various constant linear speeds. Means must be provided for stopping individual spindles as well as for starting and stopping the entire machine. Individual 2-pole 3-phase vertical induction motors rated at 40 watts, 12,000 rpm, 60 volts, and 200 cycles were selected for spindle drive. Induction motors were chosen because a sufficiently constant speed can be attained with better starting characteristics and lower cost than with the equivalent synchronous motors. The motor shafts are extended upwards and become the spindles.

Individual spindle motors are a great improvement over the endless belt which first was used because of their constant speed, low maintenance requirements, constant power consumption, elimination of dirt and oil from the surrounding air currents, and over-all flexibility. The element of cleanliness is particularly important in reducing the number of "seconds" caused by black streaks in the yarn. Reduction in power consumption, a more even twist because of the constant ratio between the spindle and take-up speeds, easier stopping of the individual spindles, a simpler design, and reduction in noise also result from the over-all electrification of this twister.

Take-up Drive. The take-up packages (one for every spindle) are surface-driven by cork covered drums on shafts running the length of the machine, one on each side. These shafts are driven by a gear motor rated 1/6 horsepower, 60 volts, 3 phase, 200 cycles, 65 rpm output speed. A common power supply holds a constant ratio between spindle and take-up speeds assuring constant twist. Change gears are provided to alter take-up shaft speed to obtain desired twist.

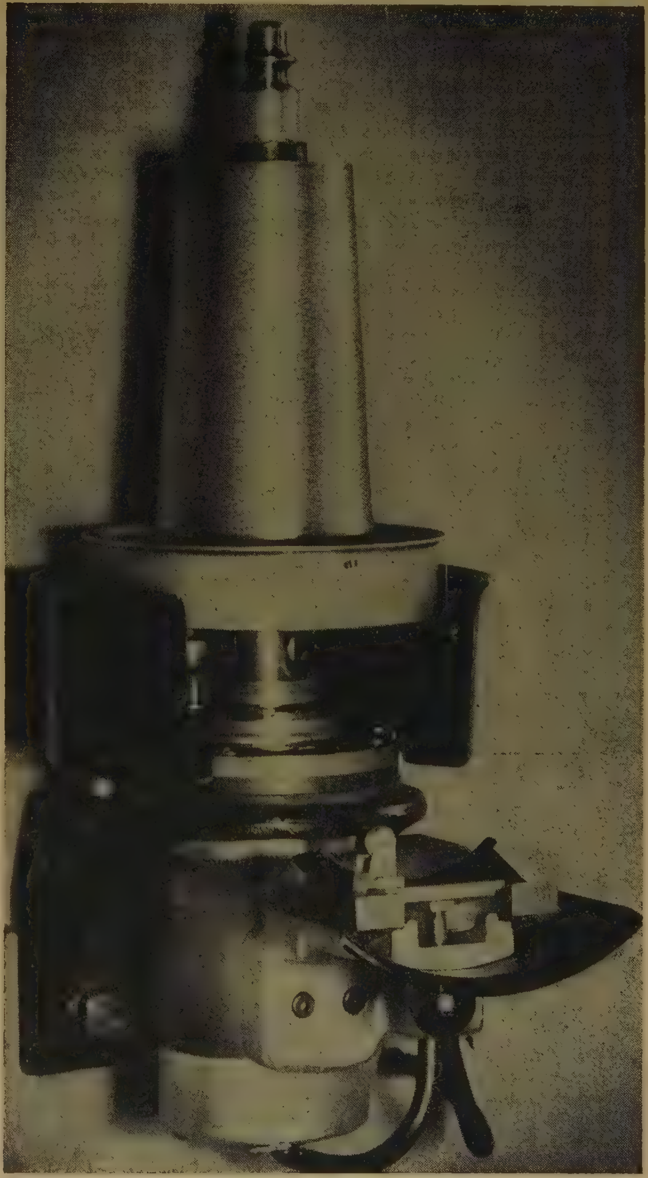


Figure 2. Electric spindle assembly with "trap door" open

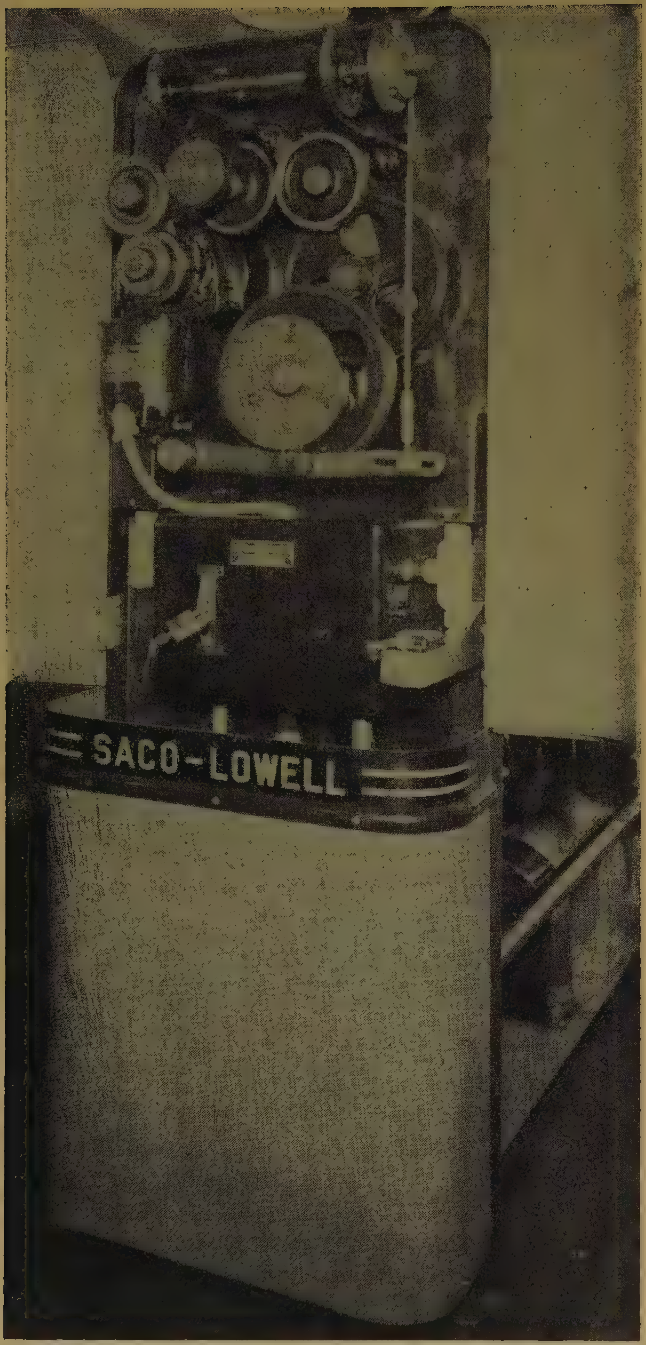


Figure 3. The head end housing with doors open to show the gear motor

Motor-Generator Set. The high-frequency power is supplied to the spindle motors by a motor-generator set which is built into each machine. Spindle speed is adjusted by changing the pulley ratio between motor and generator.

The generator is rated 3 kw, 3,000 rpm, 65 volts, 3 phase, 200 cycles. The driving motor is rated 5 horsepower, 1,800 rpm, 550 volts, 3-phase, 60 cycles.

Generator. The ratio of spindle speed to take-up speed must be held constant even during starting and stopping to avoid a stretch of yarn with bad twist. A permanent-field generator was selected rather than a separate source of excitation, thereby also providing protection against power failures. The generator uses standard stator windings with alnico magnets built into the rotating field. Extreme simplification of the circuit and the operating procedure results from the use of this generator.

In bringing the spindles up from rest to operating speed, it has proved desirable to limit the acceleration rate. The result obtained from such limitation is reduction in maximum torque requirement in the spindle motors and a tendency to more uniform relation of speeds of spindle and take-up. To insure adequate starting torque, the driving motor for the generator is designed for approximately flat torque characteristics with standstill and pull-out values about equal. Limitation of acceleration is secured by the use of a small flywheel mounted on the generator shaft which also aids in securing good starting torque.

THE COMPLETE MACHINE

The finished machine consists of a skeleton framework mounting 72 spindle assemblies, 36 on each side. The power for spindle motors is supplied from a bus bar assembly which is built into the beam supporting the spindles. The cords of the spindle motors plug into it making it a simple matter to remove individual spindle assemblies for servicing without stopping the entire machine.

A housing at one end of the machine contains the gear motor for driving the take-up and all necessary gearing as well as a cam motion to traverse the bars which guide the yarn onto the take-up spools. The housing also includes the magnetic switch for the main driving motor, two push button stations, one on each side of the machine, and a reversing switch for the spindle motors to produce the direction of twist required in the yarn being produced. The main driving motor and generator are mounted under the beam at the head end. It is so constructed that the application of power requires only the connecting of leads from the 3-phase mill power supply to the terminals of the across-the-line starter in the head end housing.

FUTURE POSSIBILITIES

It is expected that 2-for-1 twisters eventually will replace all forms of twisting except on those yarns requiring an extremely low twist and that the electrification of spindles on this machine will point the way to future electrification in the textile industry. The ever-increasing requirements for rayon tire cord can be satisfied by the 2-for-1 twister at much lower power cost. The 2-for-1 principle also is adaptable to the "Brownell" type of twisting which produces the highest known quality of plied yarns.

Television Network Facilities

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Television networks, like sound broadcasting networks, must be available to make distribution of high quality programs economical. For television circuits interconnecting studios in different cities, coaxial cable and radio relay are the most suitable methods. For short distance transmission balanced wire pairs also may be used. Local conditions will control the type circuit selected.

MORE than a quarter of a century of experience in the broadcasting of sound programs has demonstrated the necessity for interconnection of broadcasting stations. Only because the same program thus can be brought simultaneously to millions of listeners is it economically possible to present famous orchestras, singers, actors, and comedians. In no other way can on-the-scene sports and news events be brought to a nationwide audience. Television, with its still more costly programs and its even greater effectiveness for on-the-scene events, obviously also will require network interconnections if it is to become the important source of information, education, and entertainment that is predicted.

The provision of these network facilities will be a big job. Indicative of the magnitude of the undertaking are the present day sound program networks which well may serve as a pattern for future television networks. These sound program networks reach into every section of the United States, serve more than 95 per cent of the approximately 1,000 standard broadcasting stations, and employ 135,000 miles of program facilities. They represent an investment which is about one half as much as the total investment by all of the nation's broadcasters in transmitters, studios, and other physical plant.

The normal development of transmission facilities to handle the nation's communications needs is paving the way for television networks. The tremendous growth in demand for communications has encouraged the development of means for transmitting many telephone or telegraph messages over a single wide band channel. The number of messages which can be handled simultaneously has been increasing year by year until now channels are available each of which can handle hundreds of telephone conversations. Television, which uses a frequency space equal to that of hundreds of telephone messages, can be carried over this same kind of very wide band channel, and thus benefit by the joint use of the facilities provided for the many other communications needs.

Television station connection facilities divide naturally into two classes: short-haul circuits from program pickup point to studio, from studio to associated transmitter and from studio to network connection; and long-haul circuits between different cities to form television networks. Three methods are available for providing these circuits: wire pairs, coaxial cables, and radio. In a comprehensive network, all three of these methods may be used.

SHORT-HAUL TELEVISION CIRCUITS

Balanced Pairs. Wire pairs in ordinary telephone cables are used quite generally for television circuits within cities. They require certain special preparation, such as removal of bridged taps, removal of loading, special splicing between cables to obtain the most favorable routing, and in some cases special measures to reduce noise. Amplifiers are provided at short intervals to provide good signal-to-noise ratio, the exact spacing depending principally upon the wire gauge and the availability of suitable amplifier locations. For a typical case, the loss at four megacycles averages about 60 decibels per mile, and an amplifier spacing of about one mile is used. Telephone buildings sometimes are not available at the desired amplifier locations, so use has been made of rented space adjacent to the cable routes. Amplifiers are now under development which can be placed in manholes if necessary and can have power for their operation sent to them over telephone pairs.

Where several television services are needed along a route, or where a lower loss facility is advantageous, polyethylene-string-insulated shielded pairs of the type shown in Figure 1 are being included in certain new local cables to form backbone television networks within large cities. These have a loss at four megacycles of about 18 decibels per mile and any desired number can be placed in a cable without cross talk difficulty.

About 30 short-haul television circuits ranging in length up to more than ten miles have been in use

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Essentially full text of paper 47-74, "Television Network Facilities," presented at the AIEE winter meeting, New York, N. Y., January 27–31, 1947, and scheduled for publication in AIEE *TRANSACTIONS*, volume 66, 1947.

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during the past year, employing these different kinds of wire facilities. Some of them have been in service for regularly recurring programs over a period of several years.

Coaxial Cables. Coaxial cables are being used for relatively short video circuits, generally with arrangements to reduce the effect of low frequency noise induction.

Microwave Radio. Radio facilities are especially promising for unusual geographical situations. Although the present system is designed primarily for permanent installations, use probably will be found for it for temporary pickups. When a pickup of a special news or sports event from a given spot occurs only occasionally, the radio link often can be installed more quickly than a permanent type of wire link. However, radio circuits at microwave frequencies need line-of-sight transmission paths. Fading effects must be taken into account by allowing margins over the requirements for normal conditions. Through use of highly directive antennas, low power can be used and difficulties with interference and ghosts due to reflections minimized. These radio circuits have been used successfully for several pickups and demonstrations, an interesting example being a 2-link circuit between United States Military Academy, West Point, N. Y., and New York, N. Y. In some cases, combination wire and radio circuits have been used, the wire video facilities being employed to reach favorable radio sites.

LONG-HAUL TELEVISION CIRCUITS

Microwave Radio Relay. Radio operation at frequencies below about 30 megacycles has been used for point-to-point communications for many years, but it has been applied principally where the use of wire lines was impracticable. Wire communication channels have desirable characteristics which heretofore have been lacking in radio—an unlimited number can be established, the energy is precisely directed, they can be made very stable, and noise and interference can be controlled. With the development of techniques permitting the use of frequencies of thousands of megacycles, radio is beginning to approach wire lines in these respects. These improved characteristics permit the extension of radio over long distances by the use of repeaters, a method long used for wire lines.

Experiments are now under way to determine the practicability of radio relay from the standpoints of cost, performance, and reliability. A full scale radio relay system is being established between New York and Boston. Some interesting features of this system are

It will employ seven intermediate radio repeater points, the average spacing being about 27 miles for a total circuit length of about 230 miles. These repeaters are located on high points of ground so that a direct line-of-sight path is available between adjacent repeaters.

The system will employ frequencies in the vicinity of 4,000 megacycles. A total of four channels will be established, two in each direction of transmission. It is probable that a usable frequency band of at least four megacycles will be obtained for television transmission. Tests also will be made in the transmission of large bundles of telephone circuits.

The antennas will be horns with 10- by 10-foot apertures equipped with a metal lens to focus the radio waves. These antennas give a gain of about 40 decibels so that the normal attenuation of a 30-mile path between transmitters and receivers equipped with such antennas is less than 60 decibels. With a suitable allowance for fading, a satisfactory signal-to-noise ratio can be obtained for the number of sections involved in this experiment using transmitting power in the order of one watt.

It is expected that the New York–Boston system will be in experimental service before the middle of 1947. A similar system having four links looped back and forth between New York and Murray Hill, N. J., has been undergoing tests for a number of months. Preliminary indications are that satisfactory television operation between New York and Boston can be provided by this means.

Coaxial Cable Systems. Coaxial cable systems are no longer experimental transmission networks. Several hundred miles of this cable have been in commercial use for telephone purposes for a number of years. Great progress has been made in the construction of a nationwide coaxial cable network since the war. As of January 1, 1947, about 4,000 route miles of coaxial cable had been placed in the ground and construction is continuing. Figure 2 shows the cables now in place or under construction and the extensions planned for the next three or four years. The coaxial routes shown on this map total about 12,000 miles. It is expected that early 1948 will see the southern coaxial cable route ready for telephone service to points as far west as Los Angeles and that by the end of 1948, the central coaxial route will extend from New York to Chicago and St. Louis. The whole program indicated on the map may be completed by 1950.

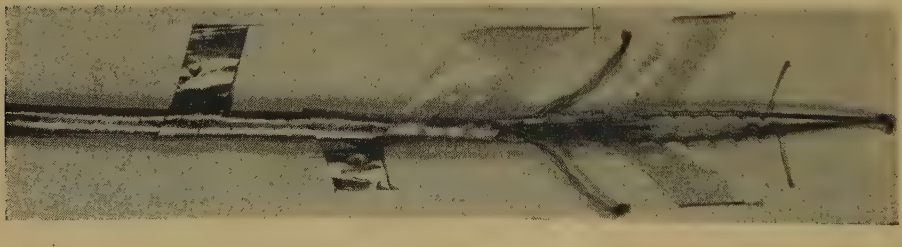
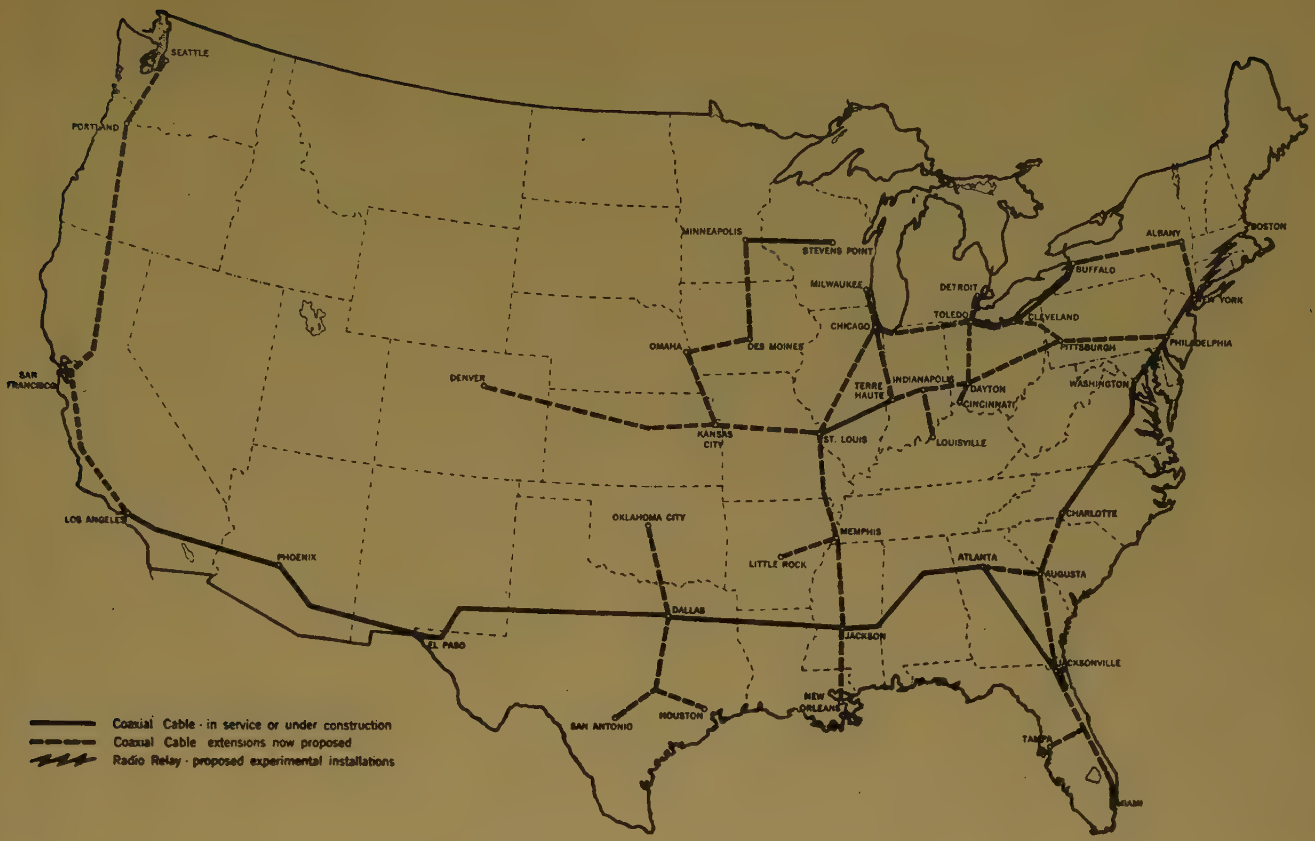


Figure 1. Polyethylene-string-insulated shielded pair for television transmission

Figure 2. Coaxial cable and radio relay networks, January 1, 1947



Coaxial cable between Philadelphia and New York was used for experimental television service in 1940 when the proceedings of the Republican national convention at Philadelphia, Pa., were transmitted to New York and broadcast by the National Broadcasting Company television station *WNBT*. Following the war, these experiments were expanded and now television circuits are in experimental service in both directions between New York and Washington, D. C. More than a hundred programs have been transmitted over these circuits, including such outstanding events as the NBC pickup of the Army–Navy games from Philadelphia in 1945 and 1946, the inauguration of the new Dumont studios, and Columbia Broadcasting System test programs in full color.

The present standard coaxial cable has an outer conductor with an inner diameter of 0.375 inch rather than the 0.27-inch diameter previously used. Polyethylene rather than hard rubber now is used for the insulating disks which are 0.08 inch thick and are placed one inch apart. This larger size coaxial has about 70 per cent as much attenuation per mile as the smaller, thus permitting wider spacing of repeaters.

Most cables contain eight coaxial conductors together with a number of paper-insulated wires for maintenance purposes. Layers of ordinary telephone pairs may be placed around the coaxial core for short-haul service needs. These cables are buried directly in the ground or placed in underground conduits. When placed in a conduit, the cable may have a plain lead sheath or, in addition, may use corrosion protection. When buried, the cable is protected against corrosion and, in addition, may have lightning protection in the form of thermoplastic layers and a copper jacket or mechanical protection in the form of steel tapes or wires.

Figure 3 shows the impedance, attentuation, and phase delay characteristics of the $^3/_8$-inch coaxial cable up to five megacycles. Limited measurements up to several thousand megacycles indicate that coaxials can be used for much wider frequency bands, the main inhibiting factor being that the attenuation increases about as the square root of the frequency.

Figure 4 shows the general layout of coaxial systems. Present arrangements provide a usable frequency band from about 64 to 3,100 kc and employ repeaters on 0.375-inch coaxial cables at about eight mile intervals. Most of these are auxiliary repeaters which are housed in small closed huts not requiring heat or power connections. These huts are designed to have very small inside daily temperature fluctuations which, combined with the general use of underground cable, reduce overall transmission variations due to short-time temperature changes to such small proportions that good equalization can be maintained. Auxiliary repeaters are fed 60-cycle a-c power over the central conductors of the cable from main repeater stations which are spaced up to 165 miles apart.

Variations in loss resulting from temperature and other changes are compensated for by regulators associated with alternate repeaters which continuously and auto-

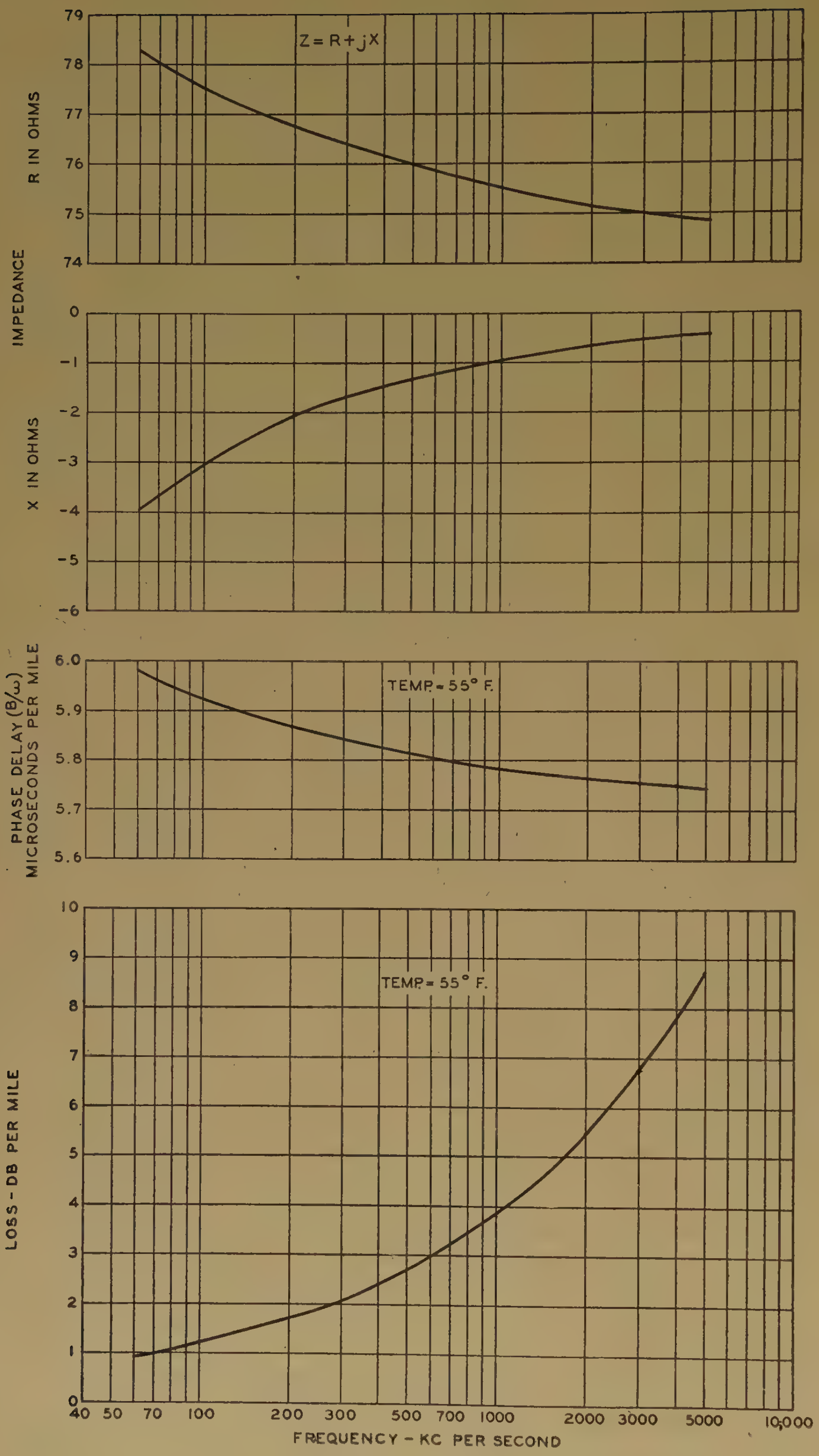


Figure 3. Characteristics of 0.375-inch coaxial cable

matically measure the output level of a 2,064-kc pilot and adjust the amplifier gain to maintain a substantially constant output level. Supplementary regulation and equalization is provided at the main repeater stations under control of four pilot frequencies sent over the coaxial line at 64, 556, 2,064, and 3,096 kc.

The 64- to 3,100-kc frequency band provided by the present coaxial line may be used either for telephone or for television transmission. When used for telephone service, terminals are provided for up to 600 circuits as required. When used for television service, the video signals to be transmitted are moved by double modulation to a carrier of 311 kc with the upper side band extending to about 3,100 kc and a vestigial lower side band extending down to about 200 kc. At the receiving end, the signals are restored to the video range by two more steps of modulation.

Sound for the television program is provided in the range from 76 to 88 kc by means of single side band program terminals which gives an 8-kc band. Wider bands can be provided if needed.

Many features have been included in the system to insure continuity of service. In addition to protection against corrosion, lightning, and mechanical damage, the cables are maintained under gas pressure with alarms to indicate any leak in the outer sheath so that repairs can be made before failure occurs. Each stage of amplification in the repeaters has parallel tubes and one tube in any stage may fail to function without interrupting service. Pilot alarms at each auxiliary repeater warn the nearest attended station of excessive pilot deviations. The power supply is arranged so that if commercial power fails, a-c power automatically will be supplied from large storage batteries through rectifier inverters or motor generators. Gas engine generators are available if the commercial power should be off for some time. Finally, a spare line is provided in each direction through each switching section, which may be up to 200 miles in length. Whenever a given coaxial line fails or gets out of limits, the spare line automatically is switched in its place so quickly that not a word is lost in any of the telephone conversations in progress, and an alarm given so that the trouble may be cleared.

SYSTEM CHARACTERISTICS

Frequency Band. The present coaxial system provides an effective video band about 2.8 megacycles in width. Even color television has been transmitted over a 450-mile circuit of this type with acceptable results.

The short-haul wire and radio facilities give video band widths of about four megacycles and the same band width is contemplated for the long-haul radio relay system to be tried out between New York and Boston.

Echoes and Gain and Phase Deviations. Echoes caused by reflections from objects in a radio transmission path or from impedance irregularities in a coaxial cable cause ghosts in television pictures and deviations in the gain and phase characteristics of the circuits. Conversely, gain and phase deviations from causes other than reflections give the same sort of picture ghosts as do echoes caused by reflections.

A large echo with a delay of, say, 3 microseconds produces a ghost about one-half inch to the right of the original object on a 10-inch picture screen. Such ghosts may be positive (a dark ghost of a dark object), or negative (a light ghost of a dark object). They may have a frequency characteristic caused by greater reflections in one part of the band than in another. For example, a high frequency echo might reproduce completely a ghost of a thin vertical line such as a flagpole, but the ghost of a wider object would show only at its edges. On the other hand, with only fairly low video frequencies (near the carrier) present in the echo, the wide object might have a large ghost but blurred edges, while the flagpole might not have a noticeable ghost. Very short delay echoes produce picture ghosts so slightly displaced that they merely blur the edges of the sharp discontinuities in the picture or affect overshoots which outline such sharp discontinuities and therefore somewhat greater amounts are allowable.

It is possible to analyze the measured gain and phase characteristics of a circuit and predict the magnitude and placing of the resultant picture ghosts. For example, if there is a plus or minus 0.8-decibel gain deviation with a corresponding plus or minus 6-degree phase deviation, each recurring regularly, the picture will have ghosts about 20 decibels down lagging the main signal. However, if the gain deviations were present without the phase deviations (or vice versa), there would be both lagging and leading ghosts, each weaker than the single ghosts just described.

Gain and phase deviations in the video band at frequencies below the line scanning rate of plus or minus 15.75 kc have a different effect than such deviations at higher frequencies. This is because they distort the pictures by making successive horizontal lines fail to match up. Also, the use of vestigial side band transmission requires special attention to phase deviations at frequencies near the carrier to insure that the two frequencies on either side of the carrier combine properly to form one in the final picture.

Ghosts in television broadcast reception have been the subject of considerable investigation and means for minimizing these effects are an important part of the broadcasting and receiving aspects of television. The magnitude of the echoes normally encountered in coaxial cables are much smaller, but in order to provide good transmission over long distances, echoes due to reflections are reduced by careful manufacture and installation of the coaxial cables. Tests to check this feature are made by means of a pulse echo method. The desired gain and phase characteristics are obtained by means of gain and delay equalizers introduced at the main repeater stations. Figure 5 shows the over-all gain and phase deviations obtained on a 225-mile New York–Washington television circuit. Television pictures have been transmitted experimentally over 800-mile circuits with satisfactory results.

Noise, Modulation, and Cross Talk. Systematic noise due to harmonics of 60 cycles may produce very objectionable patterns on the picture and resistance noise may produce general fuzziness and a boiling effect. Noise may be reduced by raising the level of the signal but this tends to increase the modulation in the repeaters. Modulation may show up as spurious patterns generally associated with sudden changes in picture brightness or may cause interference with the pilots which are used for regulating the circuit. Also, modulation into the sound program channel may occur. On the New York–Washington coaxial circuit, a ratio of peak video signal to peak noise of about 54 decibels was obtained experimentally.

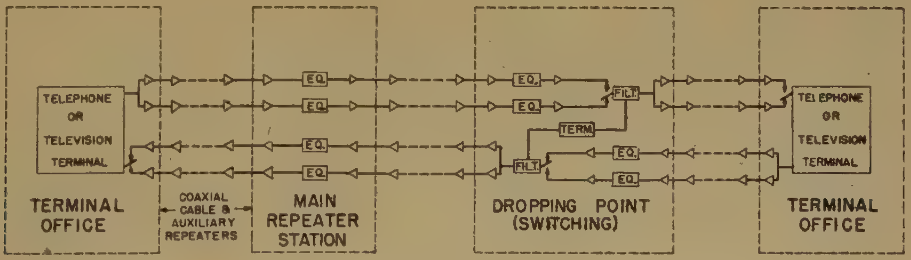

TELEPHONE OR TELEVISION TERMINAL
EQ.
FILT.
TERM.
TELEPHONE OR TELEVISION TERMINAL
TERMINAL OFFICE
COAXIAL CABLE & AUXILIARY REPEATERS
MAIN REPEATER STATION
DROPPING POINT (SWITCHING)
TERMINAL OFFICE

Figure 4. Schematic diagram of coaxial cable system

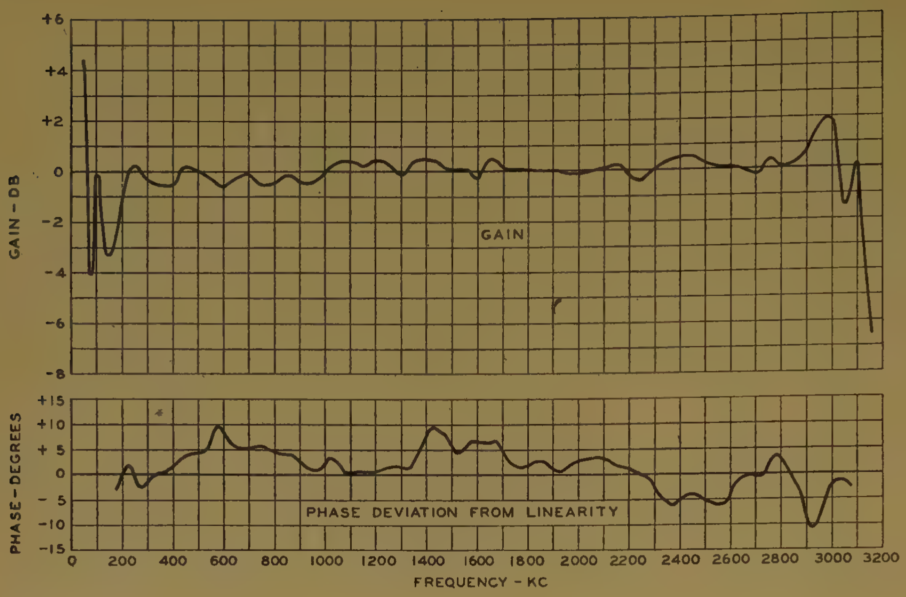


Figure 5. Attenuation and phase characteristics of the New York–Washington television circuit

Cross talk from another system tends to produce interference which shimmers, causes moving diagonal patterns, or superimposes a weak copy of the picture from the other system. This requires special attention when ordinary telephone pairs are used for video circuit. Where shielded pairs are used, and in coaxial cables, cross talk is not generally a serious problem.

FUTURE PROSPECTS

The trend to wider and wider frequency bands probably will continue. These wider bands will be needed to handle the ever increasing demand for communications and perhaps for greater definition or color television. Such wider band circuits are already under development.

Short-haul video circuits now generally transmit up to about 4 megacycles but very short studio–transmitter links have been equalized up to 10 megacycles. If such very wide band video links are needed for general local use, they can be provided by wire or radio.

The radio relay system being tried out between Boston and New York is designed for 4-megacycle television transmission over about 250 miles. Further developments are expected to make possible considerably longer circuits and, in the more distant future, wider frequency bands.

A new coaxial system now under development will use the present coaxial cable and will permit one direction of transmission for several hundred telephone channels plus a 4-megacycle television channel on each coaxial line. If still wider bands are needed for color transmission or for greater detail pictures, this system could provide a band of the order of 7 megacycles if used only for television purposes. Very much wider bands could be provided over coaxials, perhaps by the use of new types of amplifiers. These techniques may be applicable to radio relay systems also.

Still further in the future appear to be long distance circuits over wave guides and this possibility is being studied. Wave guides are merely hollow tubes without central conductors. These provide transmission paths for enormously wider bands sealed away from interference of all sorts.

It is quite clear that the future holds promise for advances far beyond the present status.

High Dielectric Ceramics

According to a recent announcement of the National Bureau of Standards, new ceramic dielectrics having exceptionally high dielectric constants have been evolved. Such dielectrics are important in the production of capacitors for use in radio, radar, and television, and for the tiny capacitors required in subminiature electronic devices.

Because the capacity of a capacitor is proportional to the value of the dielectric constant of the insulating material, a great saving of space is possible when such material has an extremely high dielectric constant. Only a few years before World War II, the very high values of dielectric constant of some of the titanates (salts or esters of titanic acid) were observed, and in 1944, at the request of the United States Army Signal Corps, the bureau began its research on ceramic dielectrics.

In current investigations at the bureau, commercial titania (98.7 per cent titanium dioxide) and reagent quality carbonates of barium, strontium, calcium, and magnesium are used. Dielectric constants for mixtures of barium and strontium titanates range from 10,000 to 18,000. The power factor for strontium titanate is 0.0001, while that for barium titanate is 0.01.

Quality Control as a Management Tool

THE term "quality control" has been given varied meanings. To some it signifies the co-operative efforts of engineers, planners, factory supervisors, and inspectors to maintain a standard of product quality; to others, the protective aspect of specific inspection and tests to guard against defects in specific items of equipment before delivery to customers; more recently, it has become confused with the methods of statistical analysis which is only one of the specialized tools through which quality control is accomplished. More correctly defined, quality control is "any organized management effort to establish and maintain required quality levels by means of suitable corrective and preventive action." The experiences of two large manufacturing organizations indicate the fundamental importance of product quality control as a top management project.

Organization of Quality Control as a Management Tool

T. D. FOY

DURING the war years the development of new designs, new machines, new methods, and processes to meet customers' demands for better service and higher quality products was accelerated far beyond any previous advancement. These new developments, as well as the rise of standardization and interchangeability of parts requiring stricter tolerance conformance, have accelerated, of necessity, the development of the statistical method of controlling quality.

Today industry is more "tolerance conscious" than ever before—it has to be. Limits of operation gradually are being narrowed to approach the nominal dimensions, and such an approach, increasing the precision with which parts must be manufactured, increases the need of exercising closer control over variations from that nominal. No longer is the mention of tolerances of plus or minus 0.001 inch startling, for attention is now turned to tenths and hundredths of a mil.

As preparation is made to meet the demand for more and better products for more people at lower costs, there is increasing recognition of the need of some organized plan whereby a high level of quality can be established and maintained in manufactured products.

In the usual manufacturing concern the use of quality control is begun on a small scale. A specific particularly troublesome or costly project is selected, the problem is analyzed using control charts, distribution curves, or sampling tables, and corrective action indicated by the data is taken, and the results (improved quality, reduced losses, and reduced costs) are tabulated and presented to management. With the approval of management, new projects for application are then determined, and the activity continues to expand and become more comprehensive as additional progress is made.

Gradually, however, it is recognized that the statistical method of controlling quality, though extremely useful in finding the cause of quality variations, is not a cure-all for manufacturing troubles. Quality is not improved, nor costs reduced, nor losses eliminated by mere statistical analysis of the problem, but rather *by the corrective action taken on the basis of this analysis.* Direction of such action requires co-operation and co-ordination, and it is on this premise that the "Organization of Quality Control as a Management Tool" is presented.

A logical decision as to the proper type of organization for quality control hardly can be made without sufficient understanding of the problem involved in controlling quality. So, for the purpose of this discussion, the following outline will be used:

1. What are the factors involved in controlling quality?
2. What is meant by quality control?
3. What is to be the purpose of the quality control organization?
4. What is to be the type of organization for quality control?
5. (Summary of) conclusions.

FACTORS INVOLVED IN CONTROLLING QUALITY

What affects quality? Where is it affected? How is it affected?

Generally, those items *which* affect quality can be classified as

1. Men.
2. Materials.
3. Processes.
4. Machines.
5. Specifications.
6. All others, such as dust, humidity, extreme temperature.

More often than not, the reasons for quality variations can not be readily allocated to just one of these items; usually it is a combination of effects more difficult to evaluate individually.

Based upon presentations made at a conference on management and quality control, June 28, 1946, held during the AIEE summer convention, Detroit, Mich.

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In a similar manner, those functions *where* quality is affected can be classified as

1. Engineering.
2. Material ordering.
3. Planning and methods.
4. Manufacturing.
5. Inspection and test.

Here again, a discussion of quality problems frequently involves more than one function of the organization before proper corrective action is obtained.

When the possible combinations of what affects quality, where it is affected, and how it is affected are fully analyzed, it is found that, for the most part, any one cause of quality variations logically might be the responsibility of any or all functions of the organization dependent upon the type of quality problem involved.

For instance, a problem involving the quality of material for a particular application might concern

1. The engineer from the viewpoint of original design, selection of material tolerances, and so forth.

2. The material-ordering personnel in the selection of vendors, and the type of quality guarantee requested.

3. The planning and methods men in the selection of machines, tools, processes, and the design of jigs and fixtures.

4. The factory personnel from the viewpoint of the skill of the operators, the machine setup, and employee morale.

5. The inspection and test divisions from the viewpoint of judging the quality of incoming material, processes and machine parts, subassemblies, and the finished product.

It can be seen that quality is affected by many different items, that several people exert varied influence upon quality, and that, to be fully effective, the organization must be set up so as to integrate the principles and coordinate the effects of the quality control program in each section of a manufacturing division.

THE MEANING OF QUALITY CONTROL

In the past, this phrase has been a source of considerable confusion, mainly because it has been interpreted in so many different ways. To some, it meant the usual over-all co-operative efforts of engineers, planners, factory supervisors, and inspectors to maintain a given standard of quality in product; to others, it meant the protective endeavors of inspectors and test men to assure quality products to the customers; to others, it meant the organized examination of test and inspection data to be used as a basis for corrective action. More recently, it meant statistical analysis methods applied to engineering and manufacturing quality problems.

The attempt to clarify this new approach to the problem of controlling quality by use of the phrase "statistical quality control" only has tended to imply that the application of these methods is restricted to special instances requiring the services of a statistical expert. Such is not the case in good practice.

There are, of course, as already mentioned, many different approaches to this problem of controlling quality; some of them have been in use for years; others, involving special techniques, are fairly new.

A practical definition of this term, therefore, which includes the good points of both the old and the new (statistical) concept of quality control is, "any organized management effort, statistical or otherwise, to establish and maintain required quality levels by suitable corrective and preventive action."

PURPOSE OF THE QUALITY CONTROL ORGANIZATION

To control the quality of the final product obviously necessitates controlling the quality of the product in all stages of the manufacturing cycle from the conception of the engineering design through the final assembly. In the past, the factory often has been the recipient of, and unknowingly held responsible for, accumulated errors in engineering design, material ordering, planning, and methods—errors which remained undiscovered until actual manufacture of the product began. Through the use of statistical quality control principles in new designs, machine and process-accuracy studies, and sampling incoming material and subassemblies, much of this can be eliminated. Industry is demonstrating the effectiveness of the quality control program in controlling the quality of the product progressively.

The purpose of the quality control organization, then, is to

1. Provide means of securing adequate data of current activity and progress, and establish the means of taking immediate corrective action at the source of trouble.

2. Provide the means of educating all personnel affecting quality to the use of quality control principles so as to secure preventive action.

TYPE OF ORGANIZATION FOR QUALITY CONTROL

With the background of the foregoing comments, the type of organization required can be presented.

Consider first, locating the quality control activity in the inspection department. In justification of such a move, it might be pointed out that no one in the organization is called upon to make more decisions regarding quality than the inspector; therefore, he knows more about what should be controlled than anyone else. Further, statistical sampling used almost exclusively by inspectors is a big part of the program to reduce manufacturing losses and inspection time. Again, it is the inspector who usually takes the data and makes the report concerning the quality of products and is thus in the best position to recommend what action is required to maintain quality.

However, quality must be built into a product; it cannot be inspected into it. Therefore, it is not believed that locating the responsibility for the quality control program in the inspection department can be fully effective. Inspection is most assuredly a part of the program; without inspection data there is little idea as to what progress is being made and where effort is to be concentrated, but the program is much bigger than the inspection department itself.

The inspector is in the best position to classify the type of poor-quality characteristics involved, that is, such off-standard items as defective castings, holes drilled off-center, oversized and undersized shafts, burrs, and poor finish. This is important, but far more important is determining the cause of the defective work and initiating the corrective action necessary to prevent recurrence of the same error in the future. This the inspector is not usually in a position to do, primarily because it is not considered a part of his job. An inspector, within the bounds of his present duties and responsibilities, no more can prevent the manufacture of poor-quality product than the fire department can prevent fires. If quality is to be controlled, the tools for controlling it must be put into the hands of the people who are exercising the most influence over it. In this way, the job is done correctly the *first* time rather than the *next* time.

Consider next the planning and methods section. Should not this be a logical place to locate the activity? A planner most certainly influences the quality of the products in his selection of the processes, methods, machines, tools, jigs, and fixtures. His position, where he can see both sides of the picture as the interpreter between engineers and factory supervisors, seems a likely place for the effective use of this method of controlling quality. But here again, although planning and methods should be a part of the quality control program, this activity is much bigger than the planning department itself. The planning man's position would be somewhat similar to that of the inspector. He could take positive action on that part of the program of controlling quality which he directly influences, but for other parts of the program, such as new-design control, sampling inspection, machine control, and assembly control, he only could recommend and suggest the action to be taken.

Similar arguments hold true to a certain degree in the case of engineering or manufacturing as possible locations for the sole responsibility of quality control activity.

Another type of organization which meets the need for such an important activity now can be presented. There is frequent use of the expression "quality control is a management tool." If this is so, and generally it is agreed that it is, direction of the quality control program logically becomes the sole responsibility of management. Such a responsibility can be delegated, but can be effective only when it is fully understood by all concerned that the delegate represents management and, therefore, carries authority commensurate with his responsibility.

In a typical manufacturing division, management is represented by an engineer responsible for the development and design of the product and a superintendent responsible for the progress of the product after the design has been completed and released for production. Those persons who are to direct the quality control program logically must report to these representatives of management, as, for example, a quality control co-ordinator in charge of the activity reporting to the superintendent, and a quality control engineer working with this co-ordinator and reporting to the engineer in charge.

With this arrangement, engineering activity under the direction of the quality control engineer and material ordering, planning and methods, manufacturing, inspection and test activities under the direction of the quality control co-ordinator can be organized to produce most effective results. In no way is this program to remove or replace the responsibility of the foreman of controlling the quality of the work under his direction, nor the planner and the engineer of their responsibility in their quality efforts. Instead, it provides them with a method of doing a better quality-controlled job through the application of distribution curves, control charts, and sampling tables to engineering and manufacturing quality problems.

In those cases where the causes of quality variation are not readily apparent or the statistical approaches appear applicable, the quality control co-ordinator can properly initiate and organize co-operative effort to find the source of trouble.

CONCLUSIONS

The reasons for setting up the activity in this manner are as follows:

1. It has the direct backing of top management which is apparent to all personnel involved.
2. It locates authority with responsibility.
3. It provides for taking positive action rather than issuing negative warnings.
4. By proper co-ordination it avoids duplication of effort.
5. It avoids resolving the quality control program into a data-analysis program which presents the story but lacks the authority to do something about it.
6. It provides preventive as well as corrective action.

The large, modern organization of today is a highly complex, intricately functionalized mechanism with tremendous division of responsibility, each function making a special contribution to the ultimate goal of building a high-quality product at low cost which will provide service according to customer requirements. This article is not intended to expound upon the virtues or faults of large industrial organizations other than to point out that with such an organization the problem of controlling quality becomes even more complicated because of the many diversified influences affecting it.

It is in contending with this problem that the quality control co-ordinator can make his greatest contribution. Not only is he concerned that the causes of quality variation be determined but also that corrective action be taken immediately by persons responsible. The fault of some quality control organizations which do not carry sufficient authority with responsibility is that such corrective action is sometimes long in coming.

As a representative of management, removed from the influence of functionalized barriers, the quality control co-ordinator can best organize and propel the co-operative efforts of those sections most vitally concerned with the quality problem.

One point which should be emphasized again is that the quality control activity must be organized to consider two approaches: corrective, and preventive.

The first is the short-range program involving the attack on specific projects in need of corrective action. Such an approach is productive of immediate results which can be evaluated in terms of quality improvement or cost reduction over some previously-established level. However, this approach, although very necessary and effective, is more or less a temporary expediency designed to overcome undesirable quality variations in products under immediate consideration. It does not usually provide adequate protection against the rise of future problems which are the outgrowth of new designs, new materials, new processes, methods, and machines.

Too much emphasis on the specific-project corrective-action approach sometimes may obscure the more lasting benefits to be derived from the viewpoint of *preventive* action *which requires greater organization and co-ordination to produce good results.* The second approach is nonetheless important. If each of the functions previously mentioned, engineering, planning, and methods, can influence the quality of a product, then each of these functions must be provided with the method of preventing undesirable variations in quality. This is the long-range program responsibility of the quality control co-ordinator and the quality control engineer—to so integrate the principles of quality control that it becomes a tool of everyday usage for doing the job right the first time. To be fully successful, such a program requires full management support, organization, and co-operation.

Plant Organization for Quality Control

D. E. DURST

THE term "quality control"[1] when reduced to its elements may be defined as the exercise of directive, guiding, or restraining action over the characteristics of an article or more specifically a product in process of manufacture or after completion.

It is the author's opinion that quality control as such implies a much broader scope of effort than the application of "statistical control" methods to those phases of manufacturing which lend themselves to the system.

We find it hard to divorce any section of quality control organization plans from the ever important problems of attaining and assuring "quality through people"—and so in setting up an organization find it necessary, in principle at least, to hold to this fundamental in devising ways and means to accomplish quality production.

At best we can only generalize on what might be the ideal plan or organization for quality control. In principle we feel that the group should be independent of any other group within the plant organization and should be responsible to the final authority within the plant organization—generally the factory manager.

We have had occasion to experience two organization systems within which the application of statistical control methods were an essential part of quality control.

In one case the group responsible for adapting the system to the operations functioned under the guidance of the technical director reporting to the factory manager—and an inspection organization reporting to the factory manager was responsible for the proper determinations, postings, and indicated corrective action.

In the second case both functions are the responsibility of the product control organization.

Large or small, the best results normally may be expected when quality control organizations function as an independent group.

The need for two distinct groups is apparent—one group consisting of those individuals who are versed in both the theoretical and the practical aspects of the system. We emphasize practical because it has been our experience that practical statisticians set up and activate the types of application most effective in plant operations. The theoretical statistician certainly has his place in the work however and seems to be of most value in very large organizations. We make the above statement on the basis that best results are obtained by the individual who can "get down" to the operators—once again quality through people—and repeat because we see no way of establishing highly effective quality assurance with any system beyond the capabilities of quality control personnel to deal with supervisory and operating personnel as people.

Once the point of application for statistical control has been determined the effectiveness of the charts will depend on how much interest is developed within the operators—assuming that limits have been established within the capacities of materials and equipment.

Practically all operators are aroused to additional effort by the graphic presentation of their accomplishment so much so that in some cases it has been observed that the operators would make much effort to prevail on the personnel operating the charts to select favorable samples, sample after correction, make entries other than actual determinations, and so on. A good rule is to allow no one to get started on such practices or to indulge in artistic tendencies. All of these detract and sometimes mislead in the evaluation of performance.

An essential part of the plan is the subsequent analysis of the data, evaluation and summarization of results for review and indicated action by those who are concerned.

Bear in mind that the primary function of any quality control organization is the service they render in the production of a quality product within the demand, and as the case may be where piece by piece inspection is involved the assurance that delivered goods meet quality standards and requirements.

Quality control is a service organization to the producer who builds into the product what can't be inspected into it—quality.

Statistical control is the latest generally speaking and probably the best tool to date which quality control personnel have offered to management and their producing organizations (and should remain so as long as we offer it) not as a cure-all but for exactly what it is, an efficient and effective measurement of performance and quality evaluation to be used in attaining quality through people.

A-C Magnets and Solenoids

L. T. RADER
MEMBER AIEE

The design and construction of single phase a-c magnets is a subject about which little has been published although these magnets possess several advantages over d-c magnets. The problems which confront a designer in this field are collected and considered in this article.

THE term electromagnet is used to denote a class of devices which convert electric energy into mechanical energy usually through motion in a straight line or in an arc of a circle. In general the motion is stopped by the physical impact of two parts of the magnetic circuit used. These devices form a very useful and broad field of electric equipment and are found in such varied devices as automatic machines of every kind, machine tools, valves, clutches, vibrators, contactors, and circuit breakers. Their outstanding characteristics are that they are inexpensive compared to motors, they are very fast acting and, given proper mechanical design, will last for millions of operations.

The subject of d-c magnets has been covered well by articles and books, but there is little published information on a-c magnets. A-c magnets differ in two important respects from other electric equipment such as motors or transformers. In the latter two classes, air gaps are nonexistent or very small compared to air leakage paths. In magnets in the open position the working air gap may be several times greater than the leakage paths. In the second particular, the ratings of motors or transformers are but slightly affected by the magnitude of the magnetizing current. In an a-c magnet the rating is determined to a major degree by the magnetizing current and so there is a great dependence on magnetic material used.

A-c magnets possess several advantages over d-c magnets. A d-c magnet generates heat only in its coil. The latter must have sufficient area to dissipate heat so that the ampere turns obtained for a certain number of watts will give the required flux density in the open position. Because the flux density for constant ampere turns decreases directly as the gap is increased, a d-c magnet in general will have a force curve which varies inversely as the square of the working air gap. This force–distance curve can be varied by putting overvoltages on the device and inserting resistance in the closed

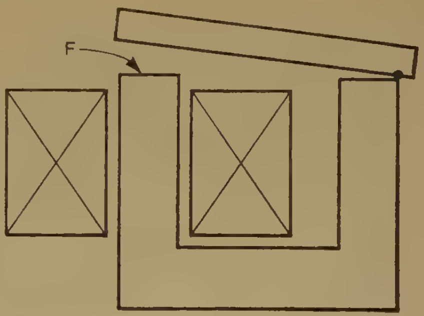

Figure 1. A single working-gap a-c magnet used for small relays

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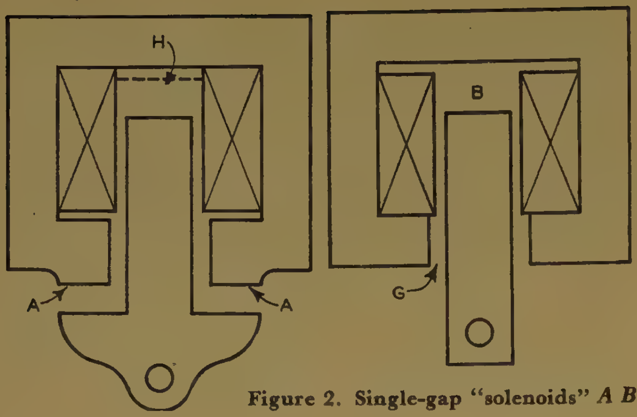


Figure 2. Single-gap "solenoids" *A B*

position but this involves additional switching means. In general the force developed in an a-c magnet tends to remain constant as the gap is opened up because of the higher current that flows due to the increased reluctance of the circuit. An a-c magnet which generates the same number of watts as a d-c magnet and has the same number ampere turns in the closed position may have as much as ten times as many ampere turns when open.

Another outstanding advantage of an a-c device over its d-c counterpart is in its speed of operation. Largely because of the laminated structure rather than a solid magnet circuit, the a-c magnet is much quicker acting than a d-c magnet when both are operated at their rated voltages.

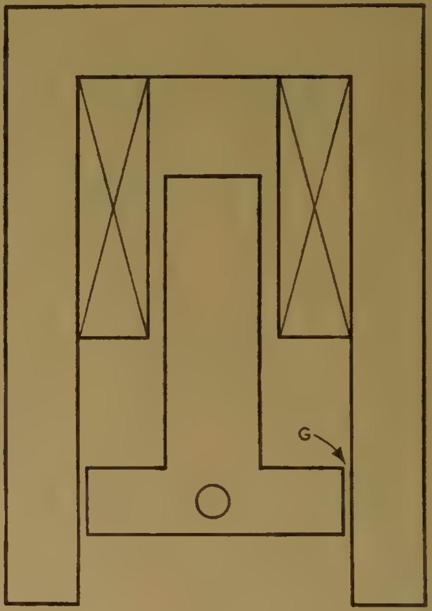
FORMS OF A-C MAGNETS

The large number of kinds and forms of a-c magnets is largely a result of their use as the motive power in specific equipments such as contactors or circuit breakers and their design to give the best curve of force– or torque–distance to suit that device. One method of classification which is very useful in comparing magnets which appear to have no common features is to segregate them into those which open their magnet circuit in one gap, and those which open it in more than one gap. Speaking generally, those magnets which open their magnetic circuit into two pulling gaps will have twice the force at half the stroke.

Figure 1 shows the common form of magnet used for small relays. This magnet usually referred to as a relay magnet is a single working-gap device which seats at face *F*. In every case the face on which the magnet seats must have a pole shader. In the very small forms the armature or moving part may be of sheet steel usually with some silicon content. In some cases the whole magnetic circuit may be of sheet steel but these are usually very inefficient devices with small force output. Figures 2*A* and 2*B* show the common form of a single gap device usually called a solenoid. The use of the term solenoid in this article is not in keeping with the AIEE standard term definition for that word. Figure 2*A* shows an electromagnet which seats at the points *AA*, and Figure 2*B* one which seats at the point *B*. Figure 3 is another form which opens a single gap and could be called a solenoid. Figure 4 shows a rotating armature, opening a gap at *D* and *E* but is essentially a single gap device since the gap at *E* contributes little or nothing to the torque. Figures 5–7 are multigap magnets. The moving members in Figures 5 and 6 either can move in straight lines or can be pivoted around a point far enough removed from the magnet so that the air gaps are opened as shown.

The a-c magnets with the exception of the very smallest usually are made of laminated silicon steel. In the smallest where core losses do not play a very important part common sheet steel or field grade iron (0.25 per cent silicon) may be used. In the larger sizes motor grade (2.5 per cent silicon)—the highest silicon-content steel with reliable mechanical properties for this kind of work—is usually used.

Figure 3. Another single-gap device



There is a form of a-c magnet made with solid material which uses either cylindrical pipe stock or iron or steel castings (Figure 8). These magnets usually develop very little force (of the order of a few pounds at 3/4-inch stroke) but have a field of usefulness as valve operators in pneumatic or hydraulic lines. The coil is totally enclosed making a possible explosionproof construction but core losses in the solid iron are very high and severely limit the size of magnet which can be made for continuous operation.

THE DESIGN PROBLEM

A strictly analytical solution for the design of an a-c magnet is seldom attempted. Assumptions which are usually made such as no saturation, neglect of leakage flux, *IR* drop, and iron losses, are so poor that a solution dependent on them is not only useless but often very misleading.

Size and rating are critically dependent on heat dissipation which includes the kind of mounting plate, method of mounting, kind of enclosure, and other sources of heat within the enclosure. This information is often unknown and must be estimated. Accordingly, design methods based on empirical data, preferably correlated through dimensionless coefficients, and guided by theory, are most successful.

To design a magnet certain specifications must be available to the designer. He must know the required load–displacement curve, the duty cycle, the quiet pull required in the closed position, the mechanical life, the dimensions to which the device must conform, and the maximum volt-amperes which can be drawn from the line. There are of course other more general specifications such as AIEE Standard 15 (ASA C19.1-1943), Industrial Control Apparatus. The design problem consists of two fundamental parts—conditions existing when the magnet is closed or sealed, and conditions when the magnet is open. The problems encountered with the magnet in the closed position, other than that of noise, are all involved with those factors producing heat and their effect on the coil temperature.

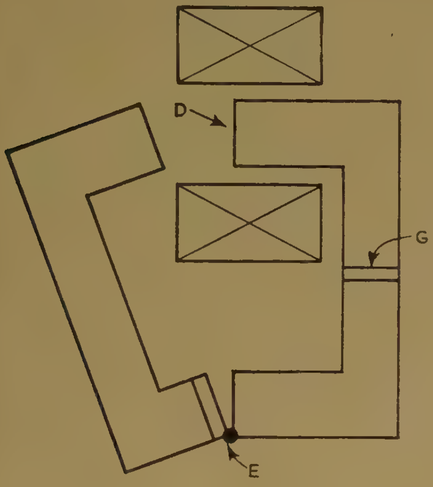


Figure 4. A single-gap rotating armature

Sources of heat can be divided into three main categories:

1. Coil I^2R
2. Pole shader loss
3. Iron and stray loss

The coil loss is a straightforward calculation if the magnetizing current can be determined. In a small magnet, say less than two pounds pull at 1/2-inch gap, the coil may generate as much as 80 per cent of the total watts of the device. Because of the relatively high coil resistance compared to the reactance, the inrush current is not much larger than the magnetizing current and the design becomes very similar to that of a d-c magnet of the same dimensions. As the magnet size gets larger the coil I^2R increases less than the other losses so that it may drop to as little as 10 per cent of the total loss.

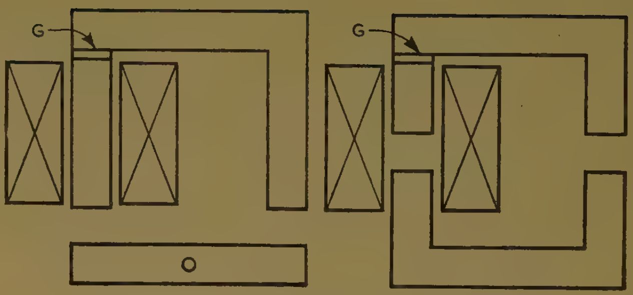


Figure 5. Multigap U magnets *A A*

The pole shader loss is usually appreciable, being 10–30 per cent of the total watts, but its significance depends largely on the physical position of the shader with respect to the coil, and the degree to which the shader heat raises the coil temperature. If the latter effect is small the shader watts are almost immaterial to the rating of the device. The inphase component of sealed-in current (usually called magnetizing current) which must flow to supply shader watts is usually negligible compared to the total current because of the low power factor of the device.

Hysteresis loss, eddy current loss, and stray losses which occur in the iron because of manufacturing processes may be classified as iron losses. It has been found that hysteresis loss of silicon steel can be greatly increased by pressures over 1,000 pounds per square inch. Figure 9 shows how the magnetizing current is affected by pressure. In riveting together laminations, pressures great enough to make the rivets completely fill their holes are used. Residual pressures around the rivet heads are usually great enough to increase the hysteresis loss considerably. Eddy current losses also can be much greater, as much as 300 per cent, than those indicated by Epstein tests. The reasons for this can be easily comprehended by considering the differences which exist between iron conditions in the Epstein test and in actual use. In the former the laminations must be held loosely with little pressure between them, the edges must be free from burrs. In production the laminations have burrs whose magnitude depends on the number of laminations which are punched between die grindings. In addition to existing at the edges these burrs exist at all holes punched out for rivets or bolts. Under the pressures used in clamping and riveting these burrs may cut into adjacent laminations and the insulating film between laminations, be it oxide or enamel or other, may be broken through in spots to increase eddy current losses.

Stray losses are usually attributable to two main sources. Faces which must be ground to ensure good seating have the laminations smeared into each other and are a source of stray loss. Rivets, together with end plates, can form short circuited loops linked by flux and often can contribute high losses. For example, if rivets are placed as at *A* and *B* in Figure 10, the flux $2\phi_1$ represents flux which links the circuit made up of *A*, *B*, and

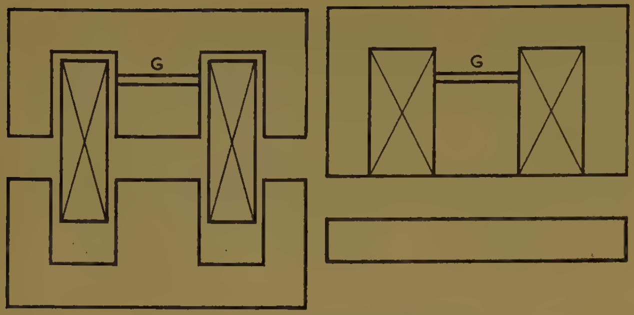


Figure 6. Multigap E magnets *A B*

the end plates which tie the rivets together. Similarly rivets *C* and *B*, or *C* and *D*, can form similar loops. In general however, the voltages generated are very small and the resistance of the circuit is large enough to keep the loss within reasonable limits. This effect governs to a considerable extent the placing of rivets. In some older designs it was the practice to place the rivets as near the outside edge as possible and open the magnetic circuit to the rivet (Figure 11*A*). In present designs the placing of the rivet is determined primarily by mechanical considerations but the loss problem still must be considered.

Bolts which hold an electromagnet to a metal base also may form part of a parasitic circuit. The circuit *abcd*, Figure 11*B*, is made up of a rivet, the end frame or mounting flange, and two mounting bolts. Watts generated in a circuit such as this can be an appreciable fraction of the total watt rating of the device.

CONDITIONS WHEN MAGNET IS OPEN

A common formula which electrical engineers try to use to find the force developed by a magnet is the B^2A formula. This states that the force developed varies directly as the flux density squared and the pulling area. This formula is almost useless in a-c magnet work because of the great difficulty in getting a usable value of B with the large working gaps involved. A more satisfactory method is in the use of a formula which involves writing the energy of the system. This principle is known as the principle of virtual displacement. Briefly it states that force is the first derivative of the total stored energy of a system.

For the electrical case the stored energy is $^1/_2Li^2$ so that the force becomes

$$F=\frac{1}{2}\frac{d}{ds}(Li^2)\ 10^7 \text{ dynes} \qquad (1)$$

This can be rewritten as

$$F=\frac{1}{2(2\pi f)}\frac{d}{ds}(ei)\ 10^7 \qquad (2)$$

where e is the reactive component of the applied voltage and

$e=2\pi fLi$

If resistance drop is neglected, e is constant and equal to the applied voltage and the equation 2 becomes

$$F=\frac{e}{4\pi f}\frac{di}{ds}10^7 \qquad (3)$$

In equation 3, F is in dynes, e in volts, i in amperes, and s in centimeters. Converting to pound and inch units gives

$$F=.703\frac{e}{f}\frac{di}{ds} \qquad (4)$$

If the curve of current versus gap at constant voltage is a straight line for a magnet then $\frac{di}{ds}$ becomes

$$\frac{i_{\text{inrush}}-i_{\text{magnetizing}}}{\text{stroke}}$$

and equation 4 becomes

$$F=.703\frac{e}{f}\frac{(i_{\text{inrush}}-i_{\text{magnetizing}})}{\text{stroke}} \qquad (5)$$

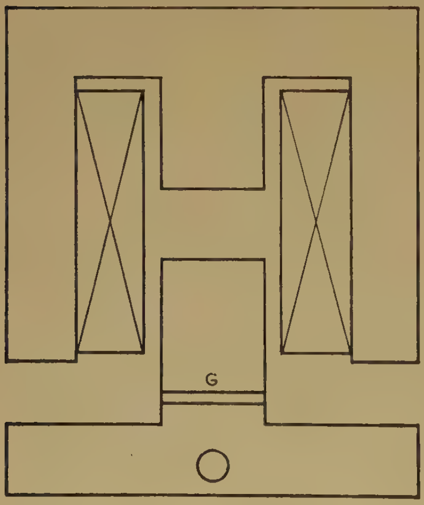


Figure 7. A variation of the multigap E magnet

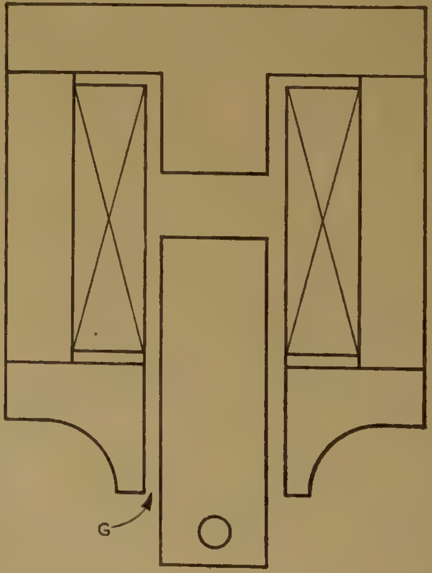


Figure 8. A solid material a-c magnet for valve operation

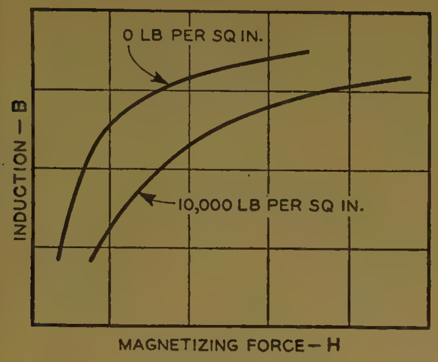


Figure 9. Magnetization curves for 3 per cent silicon sheet steel

Since both the inrush and the magnetizing currents are proportional to voltage, equation 5 shows that the force is proportional to the voltage squared. Equation 5 also states that the ratio of inrush to magnetizing current is a measure of the pull of a magnet at constant voltage. This equation also exposes the fallacy in the statement, sometimes made, that a certain force can be obtained with less current in one competitive device than can be obtained by another in the same field. If any significant differences exist, the devices compared are different in some important aspect such as perhaps operating stroke or physical dimensions. It also should be noted that this ratio of inrush to magnetizing current is a measure of force only if there is no saturation. Since saturation usually exists in the closed position the curve of current versus gap is usually a straight line only at gaps greater than 1/8 inch. Figure 12*A* shows a curve of current versus stroke representative of many a-c magnets. Figure 12*B* shows the kind of pull curve expected from a current-stroke curve as in Figure 12*A*.

The point *A* represents the sealed position where the gap may be of the order of 15 to 30 thousandths of an inch. The current increases rapidly as a gap is introduced into the magnet circuit. During the interval *B* to *C* the inductance varies linearly with stroke, the current varies linearly and the force is constant. At *C*, movement of the plunger begins to have less effect on the current, and the force decreases. When the current ceases to change with plunger movement then the plunger is essentially outside of the magnetic circuit and the force is zero. The useful range of stroke of a magnet is usually somewhere about *C*. In many cases the current increases faster than linearly with gap somewhere in the region *BC*, say at *E*. This gives rise to a force which is greater at *E* than at *C*, a not uncommon effect in a-c magnets.

In order to calculate force by this method it is then necessary to be able to calculate current in both the closed and open position. This can be done by deriving suitable coefficients from existing devices by which the N^2A (turns^2 × cross section of iron) of the design can be multiplied to get the true reactance. The resistance can be calculated from known or assumed dimensions.

RESIDUAL STICKING

In all magnets it is necessary to break up the magnetic path in the closed position by a permanent air gap. This gap may be a clearance gap as at *G* in Figures 2*B* and 3; it may be designed in to be a clearance between plunger and frame as at *H* in Figure 2*A*, or may be built in as at *G* in Figures 4, 5*A*, 5*B*, 6*A*, 6*B*, and 7. If no gap is in the circuit the residual flux for 2.5 per cent silicon steel is about 52,000 lines per square inch. This corresponds to a force of 37.5 pounds per square inch and is not much different whether the steel be of low or high silicon content. There is also some evidence to show that when the primary current is broken the pole shader itself can send flux across the faces giving rise to residual forces greater than those put in by the main magnetic circuit.

In magnets which are made with steels which may age, there is sometimes an increase in coercive force due to repeated impact and a device which is satisfactory when manufactured may develop sticking trouble with time. A good high temperature anneal usually minimizes this tendency.

A magnet sometimes is mounted in such a way that the permanent air gap is shorted through some part of the device it is operating. Figure 13 shows an instance of a magnet-operated plunger which caused trouble. When a nonmagnetic shim was placed between magnet and valve and nonmagnetic bolts and nuts used, the residual trouble disappeared.

The residual flux in the main magnetic circuit can be found by using the second quadrant of the hysteresis loop, and finding the intersection of the air gap line with the curve.

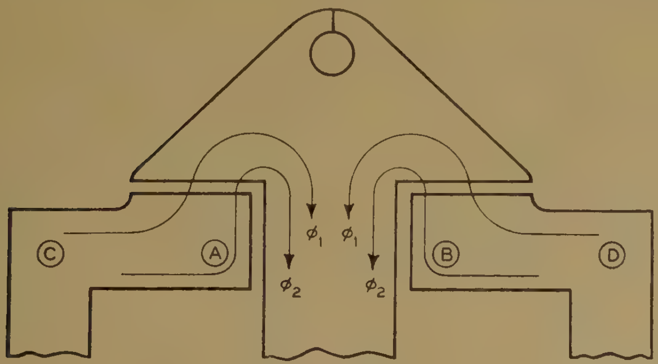
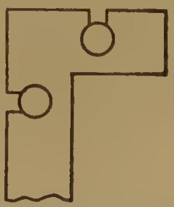


Figure 10. The influence of rivets on stray losses



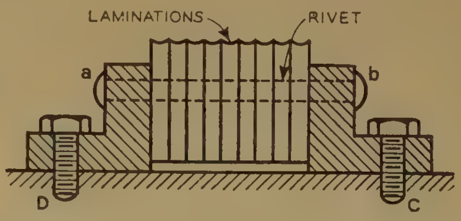


Figure 11A (left). Older designs placed the rivets near the outside edge and opened the magnetic circuit to the rivets

Figure 11B (right). The effect of rivets, end plates, and bolts on stray losses

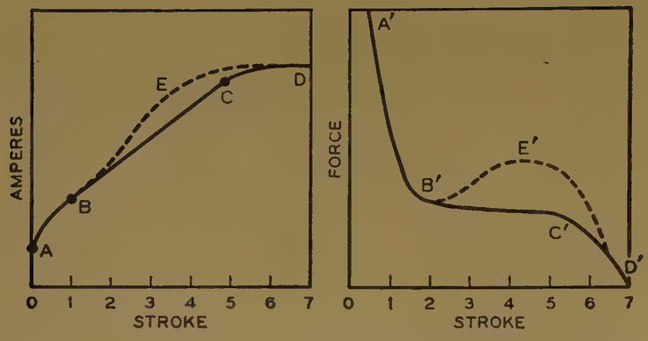


Figure 12. A typical current-stroke diagram and the resulting force-stroke diagram

A point not often appreciated is that an annealed steel usually has a residual flux, B_r, which is greater than for the annealed steel. If no air gap is in the circuit, or if the air gap is too small, the residual force is greater for the annealed steel than for the nonannealed.

MECHANICAL CONSIDERATIONS

In the magnet types exemplified by Figures 2*A*, 2*B*, and 3 the air gap *G* which exists between moving plunger and the stationary iron is very important. This gap is kept as small as possible to keep the magnetizing current low in the sealed position. Nonmagnetic guides keep the magnetic parts separated. However small mechanical clearances must exist and any unbalanced magnetic side pull is accentuated by movement of the plunger to the side having the greatest pull. This produces a wearing on the guide which is often the limiting mechanical consideration. Guides are usually made of nonmagnetic stainless steel, brass, hard copper, or beryllium copper.

After hundreds of thousands of operations the magnets may fail because of broken rivets or mounting bolts, the breaking of the pole shader, or the cracking of iron supports. The moving member may have 1 or 100 inch-pounds of energy stored up in it as kinetic energy. The time of stopping is short, the deflections are small, and the forces very high. These forces in effect subject the stationary member to impacts similar to that obtained by striking it with a hammer. In many cases the beating surfaces mushroom out or are worn away so that permanent gaps may disappear.

Magnets are kept quiet by pole shaders. It is inevitable however that on certain operations some misalignment may occur and dirt may come between magnet faces so that the magnet may vibrate or hum even though the shader may be intact. The problem of designing a shader which will withstand impact and vibration is often a very real one. Despite the very real mechanical problems diligent and continuous modifications in design have accomplished remarkable results in this field and a-c magnets give remarkably good performance and life.

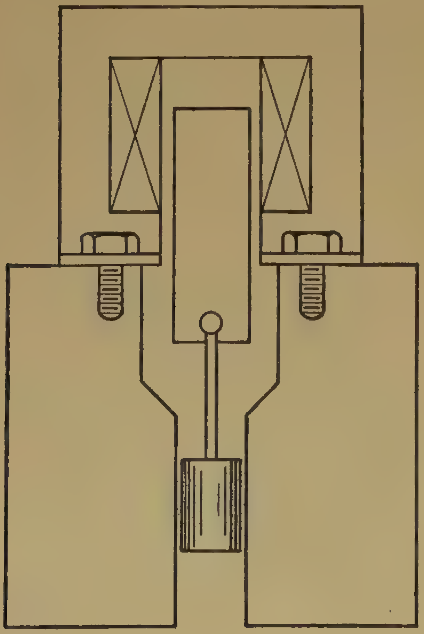


Figure 13. A magnet - operated plunger

Gas Turbine Electric Locomotive

A gas turbine electric locomotive is to be designed and built at Baden, Switzerland, for the Great Western Railway. The order for the locomotive has been placed with the British Brown-Boveri, Ltd.

The locomotive will be rated at 2,500 horsepower with a maximum continuous speed of 90 miles per hour, capable of hauling a trailing weight of 1,200 tons at speeds up to 40 miles per hour continuously. Starting tractive effort is to be 33,000 pounds. Length of the locomotive will be 65 feet, 6 inches, and the weight will be 113 tons, including enough fuel oil to make a trip of 250 miles.

Air at 45 pounds per square inch gauge will be delivered by a turbine-driven compressor through an exhaust gas heat exchanger to a combustion chamber for oxidation of the fuel. The greater portion of the compressed air will be by-passed to be mixed with the hot products of combustion, cooling them to approximately 1,100 degrees Fahrenheit before the gas is expanded through the turbine. Exhaust gases will pass through the heat exchanger where sufficient heat will be recovered to raise the temperature of the air delivered to the combustion chamber to 500 degrees Fahrenheit.

Total power produced by the turbine unit will be 10,300 horsepower, 7,800 of which will be absorbed by the air compressor. A 2,500 horsepower d-c generator will be driven through a speed reduction gear to supply series traction motors mounted on the outer axles of each of the two 6-wheel trucks. Control is to be accomplished from either of two cabs at opposite ends of the locomotive.

A less powerful locomotive of the same type was built five years ago by Brown-Boveri for the Swiss Federal Railways.

INSTITUTE ACTIVITIES

1947 Summer General Meeting Features Saguenay Boat Trip

For the 62d annual summer general meeting of the AIEE, to be held in Montreal, Quebec, Canada, June 9–13, 1947, the summer general meeting committee has planned a program of entertainment, inspection trips, and recreation, in addition to the excellent technical sessions, which should make the meeting attractive as a vacation, as well as of benefit professionally. Meeting headquarters will be at the Mount Royal Hotel, located in the heart of the city.

TECHNICAL PROGRAM

Eighteen technical sessions and nine technical conferences will make a program of broad scope, which will be of particular interest to members in eastern Canada. Two conferences on standards will have an international aspect through comparison of American and European standards on transformers, motors, circuit breakers, and system voltages. In the industrial field sessions on power supply and equipment in paper mills, a conference on electrolytic conversion equipment, a conference on operation of mercury-arc rectifiers, a session on industrial voltage requirements, and a conference on power supply for electric welding from the Canadian point of view, will be particularly appropriate. In the power field sessions on hydroelectric power generation, power transmission, power system applications of carrier current, protective devices, transformers, and a conference on telemetering form a well-rounded program. In the field of communication and science there will be sessions on communication, electronics, servomechanisms, instruments and measurements, and a conference on large-scale computing devices.

ENTERTAINMENT

Excellent programs for both men and women have been planned by the hospitality and sports committees. Among the hospitality features planned for the men are the president's reception and cocktail hour, a smoker with refreshments and entertainment, and for both men and women is the famous Saguenay boat trip.

SAGUENAY BOAT TRIP

The boat will leave Victoria Pier, Montreal, on Friday, June 13, at 6:00 p.m., arriving at Bagotville, Quebec, Canada, on the Saguenay River at 5:00 p.m., Saturday, June 14. The scenery on this trip is some of the most impressive in the world. On arrival at Bagotville a trip to the Shipshaw power development has been arranged through the courtesy of the Aluminum Company of Canada. The boat will sail from Bagotville on Sunday morning at 1:00 a.m. and on the return trip arrangements have been made for stopovers at beautiful Murray Bay, Quebec, for three and one-half hours and also at Quebec City, Quebec, from 3:30 in the afternoon until eight o'clock at night. Passengers will thus have an opportunity to visit this historic city during daylight hours. The boat will dock in Montreal at 6:00 a.m., Monday, June 16.

The boat leaving on Friday, June 13, has been completely reserved for members attending the AIEE meeting. In addition, arrangements have been made to take care of any overflow on the regular trip sailing from Montreal Saturday afternoon, June 14, and returning to Montreal on Tuesday morning, June 17.

SMOKER

Tuesday, June 10, starting at 8:30 p.m., using both the Ballroom and the Normandie Roof on the ninth floor of the Mount Royal Hotel, there will be two continuous shows. One will be on the Normandie Roof, where tables will be provided, and food will be served from 8:30 to 11:00 p.m. An orchestra will play during the evening and there will be a continuous floor show, including dancing teams, vocalists, sleight-of-hand, and other acts.

At the same time a carnival type of show will be in continuous operation in the Ballroom. Beer will be available at a bar in this room and there will be continuous orchestra music, boxing matches, games of chance, tumbling acts, juggling, and other entertainment.

Accommodation will be limited to 900 and it is suggested that reservations should be made at the earliest possible date.

Future AIEE Meetings

Summer General Meeting
Mount Royal Hotel, Montreal, Quebec, Canada, June 9–13, 1947

Pacific General Meeting
San Diego Hotel, San Diego, Calif., August 26–29, 1947

Middle Eastern District Meeting
Biltmore Hotel, Dayton, Ohio, September 23–25, 1947

Midwest General Meeting
Congress Hotel, Chicago, Ill., November 3–7, 1947

Winter General Meeting
William Penn Hotel, Pittsburgh, Pa., January 26–30, 1948

Tentative Schedule of Events

(Eastern Daylight Saving Time)

Monday, June 9

Morning	Registration
9:30 a.m.	Land transportation
	Conference on education
	Industrial voltage requirements
10:30 a.m.	Delegates' get-together
2:00 p.m.	Conferences on Section operation and management
	Large Sections
	Intermediate Sections
	Small Sections

Tuesday, June 10

9:30 a.m.	Conference on Student Branches
	Conference on standards
	Power supply in paper mills
2:00 p.m.	Conference of officers, delegates, and members
	Conference on standards
	Equipment in paper mills
	Golf
3:30 p.m.	Women's fashion show and tea
Evening	Women's bridge and light supper
8:30 p.m.	Smoker

Wednesday, June 11

10:00 a.m.	Annual meeting
	Women's Laurentian Mountains tour
Afternoon	Inspection trips
	Golf
2:00 a.m.	Special conference on technical activities
	Power transmission
	Servomechanisms
	Communication (modulation)

Thursday, June 12

9:30 a.m.	Hydroelectric power generation
	Instruments and measurements
	Industrial control devices
	Safety
12:30 p.m.	Board of directors' luncheon
1:00 p.m.	Women's sightseeing tour and tea at Botanical Gardens
2:00 p.m.	Power transmission
	Communication (general)
	Conference on electric welding
	Conference on electrolytic conversion equipment
Evening	President's reception and dance

Friday, June 13

9:30 a.m.	Transformers
	Power system applications of carrier current
	Conference on electrolytic conversion equipment
	Conference on large-scale computing devices
2:00 p.m.	Protective devices
	Rotating machinery
	Conference on telemetering
	Conference on operation of mercury-arc rectifiers
6:00 p.m.	Saguenay boat trip

WOMEN'S ENTERTAINMENT

An interesting program has been prepared for the women. Open house will be held all day Monday, June 9, for the women in one of the Mount Royal Hotel salons, where they may avail themselves of the opportunity to meet old friends and to make new ones.

On the following day, there will be a fashion show and tea at one of the leading Montreal department stores at 3:30 in the afternoon. On Tuesday evening, June 10, arrangements have been made to hold a card party at the Mount Royal Hotel. A light supper will be served and plenty of prizes distributed for the women.

One of the features of the women's entertainment will be a Laurentian Mountains tour. On Wednesday, June 11, busses will leave the Mount Royal Hotel at 10:00 a.m. and return towards 5:00 p.m. This tour, which consists of a 100-mile trip through a region covered with lakes and rivers in a mountainous setting, presents an excellent opportunity to view the playground of eastern Canada. This area long has been a paradise for the hunter and fisherman in the summer and is, in addition, a very famous winter resort for the skier. Lunch will be served at the Alpine Inn, where the guests may walk about and view the exceptional scenery.

Arrangements have been made for a sightseeing tour of Montreal, ending with a visit to the Botanical Gardens on Thursday afternoon, June 12. Busses will leave the Mount Royal Hotel at 1:00 p.m. and return at 4:30 p.m. During the tour there will be an opportunity to visit many of the main points of interest within the city such as St. Joseph's Shrine, Notre Dame Cathedral, the old business area with its narrow streets, the city buildings, the Chateau de Ramezay, constructed in the 18th century and now being used as a museum, the markets, harbor, parks, and residential areas. Towards the end of the tour, tea will be served at the Botanical Gardens.

GOLF

The sports committee is making arrangements for a full golfing program.

INSPECTION TRIPS

Visitors are invited to inspect the Beauharnois power development. This development is one of Canada's largest hydroelectric installations and is located on the shores of Lake St. Louis, some 22 miles west of Montreal. The powerhouse itself is over 1,000 feet long and contains 14 generating units aggregating 650,000 horsepower. The development utilizes the normal drop of 82 feet between Lake St. Francis and Lake St. Louis on the St. Lawrence River.

Between Montreal and Beauharnois visitors are afforded an excellent view of rural Quebec, its winding roads, miles of beautiful scenery, and quaint habitant farms. On the trip one of the points of interest will be the Indian village of Caughnawaga, founded in 1716, which still retains much of its early atmosphere.

Montreal is the largest city in Canada with a population of over one million. It is the third largest French speaking city in the world and truly named the Paris of America. Gracing the banks of the St. Lawrence, with its quaint historic structures reminiscent of the days of Jacques Cartier, magnificent churches, significant of the faith of its French-Canadian citizens, Montreal offers to the visitor a treasure of scenic interest.

A tour has been arranged, exceeding two hours in length, in which visitors will see Montreal at its best. During the tour, visitors will visit the unequalled Notre Dame Cathedral, the Chateau de Ramezay, built in the 18th century as the Governor's Residence, St. Joseph's Oratory (a world famous shrine), McGill University, Montreal's beautiful residential areas, factory districts, financial centers, the old French district, and many scenic subjects.

For visitors interested in nuclear research, an inspection trip has been arranged to the cyclotron laboratory at McGill University. At the time of its undertaking this cyclotron was of unique design and the largest of its type. Much of Lord Rutherford's early work in nuclear physics was done at McGill and since then the university has contributed many prominent names connected with the developments leading to the atomic bomb. It is not expected that the cyclotron will be completed at the time of the meeting, but the visitors will be able to see many components of this highly complex machine in a state of assembly.

Hotel	Rates Double
Mount Royal (headquarters)	$6.60 up
Berkeley	6.00 up
de La Salle	4.00 up
Queens	4.00 up
Ritz-Carlton	6.00 up
Windsor	5.50 up

To those visitors taking the boat trip from Montreal to the Saguenay, the inspection trip committee has arranged a special side journey of outstanding engineering interest. Visitors will be taken from the boat to the Shipshaw development of the Aluminum Company of Canada. The Shipshaw development comprises two generating stations with a total installed capacity of 1,500,000 horsepower. The first stage of the development was commenced about 1926 and completed in 1931 with an installed capacity of 300,000 horsepower. The second stage of the development commenced in 1941 and in the remarkably short time of 18 months the first generator was running. This project is believed to be one of the moss monumental construction jobs ever undertaken and is tangible evidence of Canadian hydroelectric engineering. The Number 2 powerhouse has 12 100,000 horsepower generators installed, making it the greatest powerhouse in the world. In addition to the above trip, the inspection trips committee has arranged for limited commercial airline accommodations on June 11 for visitors who, by force of circumstances, are unable to spare the time for the boat trip. This trip can accommodate only 28 persons and visitors wishing to take advantage are cautioned to request space well in advance. Accommodation will not be held later than 10 a.m., June 10.

HOTEL ACCOMMODATIONS

The hotel committee has been fortunate in securing block reservations at a group

Shipshaw power development

Beauharnois development

of hotels, the names and rates of which are listed. All are within a short distance of the meeting headquarters.

Single rooms will not be available. To facilitate the work of the committee, members and guests should indicate with whom they desire to share a room or, preferably, make a joint reservation.

RESERVATIONS

Members and guests should make their reservations for all events now, especially for their hotel accommodation and the Saguenay boat trip. Address all requests to Mr. G. H. Gillett, c/o Canadian General Electric Company, 1000 Beaver Hall Hill, Montreal, Quebec, Canada.

AIEE PROCEEDINGS Being Distributed

The first available sections of 1947 AIEE *PROCEEDINGS* have been mailed to those members who placed orders for them, and distribution of other sections is proceeding as rapidly as printing can be completed. *PROCEEDINGS* sections are being published in pamphlet form, each pamphlet comprising a technical paper with its related discussion, if any.

AIEE *PROCEEDINGS* are issued in accordance with the revised publication policy that became effective in January 1947 (*EE, Dec '46, pp 576–8; Jan '47, pp 82–3*). These publications are intended for the technical specialists who desire the full formal text of technical papers together with discussions prior to the distribution of the annual volume of AIEE *TRANSACTIONS*, of which *PROCEEDINGS* is essentially a preprint. The substance of all *PROCEEDINGS* sections is made available to the entire AIEE membership in *ELECTRICAL ENGINEERING* in abstract, condensed, or full form depending upon the general interest in the subject matter.

Order forms for AIEE *PROCEEDINGS* sections appear in *ELECTRICAL ENGINEERING* from time to time as papers are released by the AIEE technical program committee for publication. The form for the winter general meeting appeared in the February 1947 issue of *ELECTRICAL ENGINEERING* (pp 33A, 34A), and the one for the Northeastern District meeting and the summer general meeting is scheduled to appear in the June issue. Because discussions may not become available for printing until several months after the meeting at which papers are presented, the filling of some orders is subject to considerable delay. Over-anxious members have been found to contribute to the delay because of the time required to answer inquiries, which can be handled by the publications staff only at the expense of other duties.

Annual Meeting

The annual meeting of the American Institute of Electrical Engineers will be held at the Mount Royal Hotel, Montreal, Canada, at 10 a.m., Wednesday, June 11, 1947.

At this meeting, the annual report of the board of directors and the report of the committee of tellers on the ballot cast for the election of officers will be presented. The Lamme Medal will be presented to John B. MacNeill (F '42), and awards of Institute prizes will be announced.

Such other business, if any, as properly may come before the annual meeting may be considered.

Signed H. H. HENLINE
Secretary

Wagner Act Opinion Poll Distributed to AIEE Members

An opinion poll to guide further action by the Institute, together with a letter from President J. Elmer Housley, was distributed to AIEE members recently to determine whether they were in favor of exempting professional employees from the provisions of the Wagner National Labor Relations Act. The poll included three other questions as to type of position (supervisory or otherwise), type of AIEE membership, and age goup of the member.

The Institute is participating jointly with five other engineering societies in support of Senate bill 360 and House of Representatives bill 1754, which would give professional employees freedom of choice in accepting or rejecting collective bargaining. These bills would prevent the arbitrary inclusion of engineers in unions by prohibiting the forced grouping of professional and nonprofessional employees in bargaining units.

Advertising Director

J. S. Lopes has been appointed advertising director of ELECTRICAL ENGINEERING succeeding H. A. Johnston, former advertising manager. Mr. Lopes was formerly advertising manager for Crocker-Wheeler Electric Manufacturing Company, Ampere, N. J.

Midwest General Meeting Concurrent With National Electronics Conference

The Midwest general meeting will be held November 3–7, 1947, with headquarters at the Congress Hotel, and the National Electronics Conference will be held November 3–5, with headquarters in the Edgewater Beach Hotel, both in Chicago, Ill. Overlap of the two meetings was arranged in order that people interested in subjects on both programs could avoid traveling to two meetings at different times.

The AIEE wishes to co-operate with the National Electronics Conference and will avoid insofar as possible the scheduling of electronics papers and those which deal with the applications of electronics to the power field during the first three days of its meeting. Arrangements will be made for a joint AIEE-NEC session on electronics to be held at the Edgewater Beach Hotel. Negotiations for all electronics papers should be made through the AIEE committee on electronics, W. C. White, AIEE representative on the National Electronics Conference Board.

Prospective authors of all electronics papers should submit titles and brief abstracts at least four months in advance of the meeting. (For 1947 this date is before July 1.) Papers for the National Electronics Conference which are candidates for the AIEE *TRANSACTIONS* will be considered on the same basis as other papers for general meetings. Authors should state, when submitting papers, whether they wish to have them considered as AIEE technical papers or papers for publication in the NEC *Proceedings*. All NEC papers which are candidates for Institute publication and all papers for the Midwest general meeting should be submitted in standard form to the secretary of the technical program committee, AIEE headquarters, 33 West 39th Street, New York 18, N. Y.; three to five copies, 75 days in advance of the meeting. (For 1947 this date is August 21.) Authors not familiar with the standard form requirements should obtain the booklet "Information for Authors."

Professional Activities Subcommittee Reports for 1946 on Organization of Engineering Profession

Editor's Note: The AIEE board of directors has authorized publication of this draft of the summarizing report of the subcommittee on professional activities[*] of the AIEE committee on planning and co-ordination and has taken the whole project under advisement for further study

This report of the professional activities subcommittee is the result of a broad program of proposals and discussions and of questions seeking the views of active members of AIEE on the subject of "a preferred plan for co-operative organization of the engineering profession." The need for this consideration and some aspects of the problem seem clear as a result of comments at various meetings, on the subcommittee's questionnaires, and in engineering publications.

A critical study by the subcommittee concludes that engineers should cease to organize solely in specialized groups, if they expect to function effectively as an institution of public service. They should be reviewing the trend and should set about protecting themselves against their own enthusiasm. There should be no further delay in taking a realistic look at what has happened and what is continuing to happen to the position of the engineering profession. Representatives of the various fields of engineering should seek ways and means to correct the present weakening influences. Out of those deliberations should come a workable over-all organization for engineers.

The idea of a single professional engineering organization is not new. But for groups of men to have sufficient funds at their disposal to conduct a serious study of how such an organization might best be brought into existence is new. The problems involved are legion and they are of real proportions, but they are not incapable of solution, if long-standing precedents and perhaps some prejudices can be terminated and the maze of existing conditions are attacked with courage, good will, and understanding.

The advantages of professional unity are understood by everyone who has at heart a desire to be recognized as a member of a profession and who has a deep interest in a greater public service. While most engineers are practical minded enough not to expect the miracle of perfection overnight, they demand that a start be made on a program that will lead to a greatly improved form of professional organization.

The subcommittee has recognized fully that the task of perfecting an ideal organization of the profession is beyond the ken of a small group, and the plan presented here is necessarily in skeleton form. Further long and thoughtful deliberation on the part of many in the various fields of engineering, all working together in harmony toward the proposed common goal, will be required.

A strong tide of interest is running in engineering circles concerning the economic and public status of the profession. Many engineers, particularly our younger men, are outspoken in the opinion that the agencies which have served us so well in advancing the science and art of engineering are ill-adapted to cope with the problems and interests we face in common. The subcommittee on professional activities, appointed in 1945 by the Institute's committee on planning and co-ordination, presents here an extensive sampling of opinion among electrical engineers as to the best means of remedying this situation.

The general subject of the organization of the engineering profession at national, regional, and local levels is under active study by a committee of the Engineer's Joint Council, under the competent chairmanship of Past President Nevin E. Funk. The sponsors of this report have gathered the information here presented in the hope that a broad sampling of opinion within one of the major branches of the profession would be helpful to the council's committee, both as an indication of the interest and thinking of our members and as a stimulus to similar inquiries in sister societies. *(A statement prepared by Past President W. E. Wickenden on behalf of a committee of the president and four immediate past presidents[†] appointed by the board of directors at its January 1947 meeting to review this committee report and recommend action to the board.)*

SCOPE OF SUBCOMMITTEE ASSIGNMENT

The scope of assignment to the professional activities subcommittee is contained in "Memorandum for the Committee on Planning and Co-ordination" dated September 13, 1945, from W. E. Wickenden, then president of the Institute. Full text of the memorandum follows:

"The Institute is confronted by problems of growing urgency in its relations to both the engineering profession-at-large and the more highly specialized organizations and interests within its own general field. During the present administrative year it is hoped that these matters may receive careful consideration by the committee on planning and co-ordination, with a view to prompting whatever action by the directors may seem necessary or desirable.

"The relations to the profession-at-large extend outward in expanding circles from the fellow Founder Societies at the core to innumerable local and special organizations in intermediate zones and to the ultimate individuals at the periphery. Developments have been evolutionary, vested interests are intrenched solidly, and the situation admits of only limited rationalization.

"The Institute's relations to more highly specialized groups and interests, exemplified by the Illuminating Engineering Society and the Institute of Radio Engineers, appear in retrospect to be the fruit of tardy or possibly inadequate initiative by so large and comprehensive a body in areas of rapidly developing special interest. Parallels exist within the mechanical area, where it would seem that positive aid and encouragement to fragmentation or organization was given by the major body. In both events, policy seems to have been passive rather than anticipatory, until an accomplished fact had to be dealt with.

"Without wishing to exhaust the matter, experience seems to have substantiated certain inferences which might serve as a point of departure for a new approach to these problems:

1. Engineers can contribute best to progress in the technical arts and sciences, to the education of students and novices, to the advancement of practitioners in professional competence, and to the initial formulation of standards and other forms of codified experience in groups having a well-recognized common area of distinctive interest.
2. Standards, whether technical, educational, or professional, require co-ordination to be fully valid and to obtain wide acceptance.
3. Measures necessary or desirable for the economic, social, and individual welfare of engineers are a common concern of the profession and belong in the realm of federated or over-all organization, alike at the national, regional, and local levels.
4. Matters of public policy, legislation, and administration are also a common concern of the entire profession and belong within the realm of federated or over-all organization at the afore-mentioned levels.
5. Contributed public services by engineering group

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[*] Members of the subcommittee on professional activities are: T. G. LeClair (F '40) *chairman*, M. S. Coover (F '42), W. S. Hill (M '30), B. D. Hull (F '39), F. E. Sanford (M '34), and G. B. Smedley (A '41).

[†] Members of the committee are: N. E. Funk (F '34), H. S. Osborne (F '21), C. A. Powel (F '41), W. E. Wickenden (F '39), and President J. E. Housley (F '43).

and organizations belong primarily within the realm of joint action, and only secondarily within areas of specialized action.

6. Over-all organization, either comprehensive or functional, is of limited effectiveness and stability if existing on the national scale alone without a grass-roots counterpart.

7. Group organizations for the advancement of art, science, education, professional competence, standardization, and the like, when set up on a comprehensive scale, experience difficulty in adapting their structure and activities promptly to new developments, and are consequently subject to attrition and competition by special purpose organizations set up within their general field.

8. Special purpose organizations, in general, are less likely to insist upon professional standards in the admission of members and are quick to emphasize a narrower but more detailed coverage of their field, appealing thus to young men who have not yet attained too broad interests and responsibilities and seeming to offer them a larger immediate return for membership costs.

9. Any possibility of reintegration of special purpose or satellite organizations with major societies seems to depend upon provision within the major body for semiautonomous divisions, organized to provide a fair equivalent for the special services rendered by the minor body and to permit a limited affiliation without professional ranking.

10. A somewhat different type and plan of staff organization is needed when planning and initiative in adapting a major agency to changing conditions are included in its responsibility, as well as the efficient operation of a long-established pattern of activities.

"Your group is familiar with the well-established agencies for federated action on functional lines among the Founder Societies; also the efforts to develop the Joint Conference Committee of presidents and secretaries into a Joint Council exercising semiautonomous powers. You also are well acquainted with the efforts of the national, state, and local societies of professional engineers to win recognition as over-all agencies of the profession. Competition with the Institute of Radio Engineers for members and activity in the area of communication and electronics generally is approaching the embarassing stage.

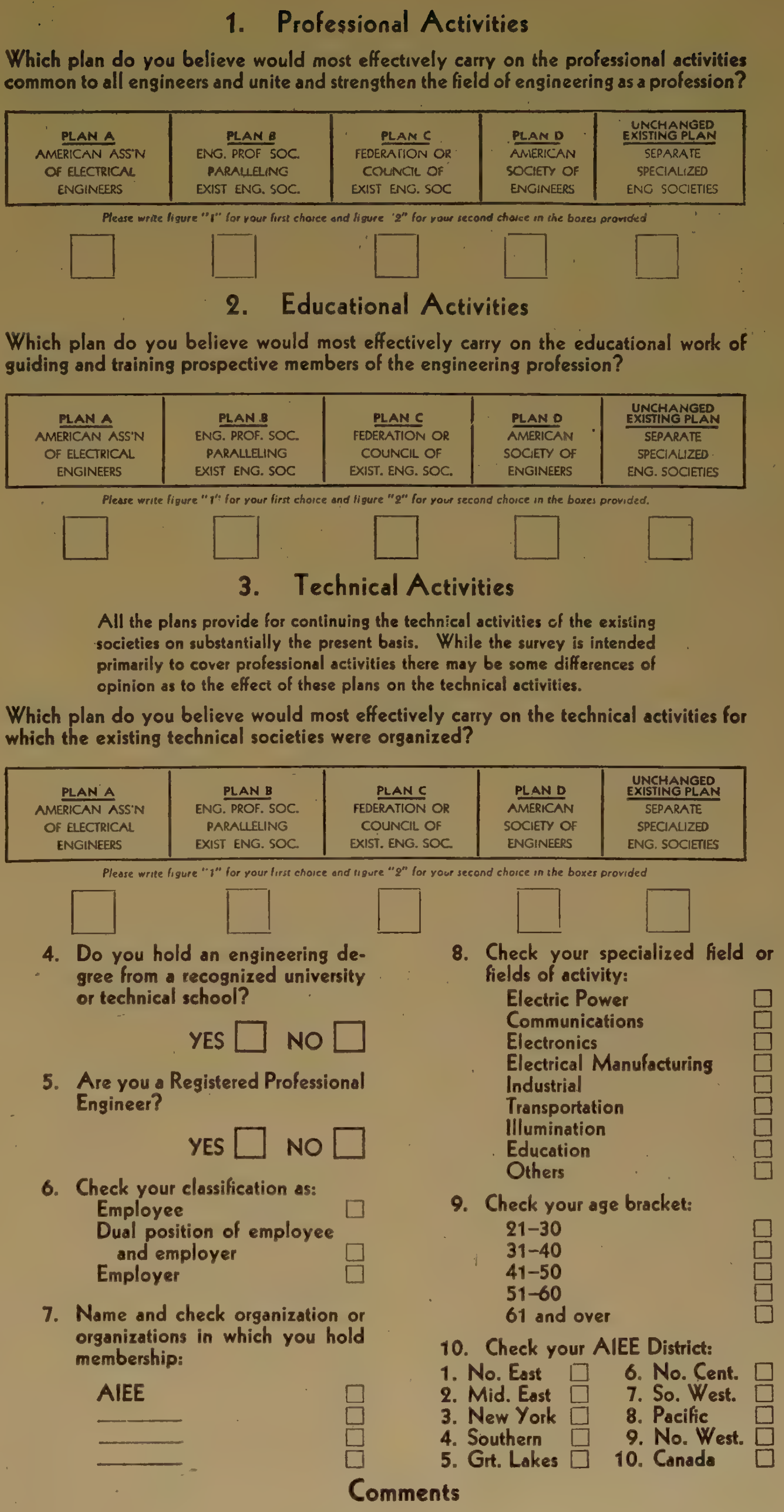
"It will be a great service to the Institute to have your committee give a searching study to the whole field of intersociety relationships and to the adequacy of our internal committee, Section, and staff organization, both to deal with developments constructively and to serve the interests of our own members within their natural subdivisions of activity."

As chairman of the committee on planning and co-ordination, J. F. Fairman, in his letter of September 19, 1945, appointed two subcommittees, one on technical activities and the other on professional activities.

As it relates to the subcommittee on professional activities, his letter stated: "The professional activities subcommittee will review the organization, methods of operation, and scope of the professional activities of the Institute and of other engineering and scientific societies to the extent necessary to enable them to prepare recommendations for changes in organization, improvement in methods, and amendment of scope in order

(a). That the maintenance of a high professional standing among its (the Institute's) members and among the members of the engineering profession as a whole may be pursued more effectively

1. By a maximum of co-operation and minimum of



1. Professional Activities

Which plan do you believe would most effectively carry on the professional activities common to all engineers and unite and strengthen the field of engineering as a profession?

PLAN A AMERICAN ASS'N OF ELECTRICAL ENGINEERS	PLAN B ENG. PROF. SOC. PARALLELING EXIST. ENG. SOC.	PLAN C FEDERATION OR COUNCIL OF EXIST. ENG. SOC.	PLAN D AMERICAN SOCIETY OF ENGINEERS	UNCHANGED EXISTING PLAN SEPARATE SPECIALIZED ENG. SOCIETIES

Please write figure "1" for your first choice and figure "2" for your second choice in the boxes provided

☐ ☐ ☐ ☐ ☐

2. Educational Activities

Which plan do you believe would most effectively carry on the educational work of guiding and training prospective members of the engineering profession?

PLAN A AMERICAN ASS'N OF ELECTRICAL ENGINEERS	PLAN B ENG. PROF. SOC. PARALLELING EXIST. ENG. SOC.	PLAN C FEDERATION OR COUNCIL OF EXIST. ENG. SOC.	PLAN D AMERICAN SOCIETY OF ENGINEERS	UNCHANGED EXISTING PLAN SEPARATE SPECIALIZED ENG. SOCIETIES

Please write figure "1" for your first choice and figure "2" for your second choice in the boxes provided.

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3. Technical Activities

All the plans provide for continuing the technical activities of the existing societies on substantially the present basis. While the survey is intended primarily to cover professional activities there may be some differences of opinion as to the effect of these plans on the technical activities.

Which plan do you believe would most effectively carry on the technical activities for which the existing technical societies were organized?

PLAN A AMERICAN ASS'N OF ELECTRICAL ENGINEERS	PLAN B ENG. PROF. SOC. PARALLELING EXIST. ENG. SOC.	PLAN C FEDERATION OR COUNCIL OF EXIST. ENG. SOC.	PLAN D AMERICAN SOCIETY OF ENGINEERS	UNCHANGED EXISTING PLAN SEPARATE SPECIALIZED ENG. SOCIETIES

Please write figure "1" for your first choice and figure "2" for your second choice in the boxes provided

☐ ☐ ☐ ☐ ☐

4. Do you hold an engineering degree from a recognized university or technical school?

YES ☐ NO ☐

5. Are you a Registered Professional Engineer?

YES ☐ NO ☐

6. Check your classification as:
   - Employee ☐
   - Dual position of employee and employer ☐
   - Employer ☐

7. Name and check organization or organizations in which you hold membership:

AIEE ☐
________ ☐
________ ☐
________ ☐

8. Check your specialized field or fields of activity:
   - Electric Power ☐
   - Communications ☐
   - Electronics ☐
   - Electrical Manufacturing ☐
   - Industrial ☐
   - Transportation ☐
   - Illumination ☐
   - Education ☐
   - Others ☐

9. Check your age bracket:
   - 21–30 ☐
   - 31–40 ☐
   - 41–50 ☐
   - 51–60 ☐
   - 61 and over ☐

10. Check your AIEE District:
   - 1. No. East ☐
   - 2. Mid. East ☐
   - 3. New York ☐
   - 4. Southern ☐
   - 5. Grt. Lakes ☐
   - 6. No. Cent. ☐
   - 7. So. West. ☐
   - 8. Pacific ☐
   - 9. No. West. ☐
   - 10. Canada ☐

Comments

Figure 1. Questionnaire used in surveying AIEE membership opinion on the organization of the engineering profession

duplication of effort as between the Institute and other organizations.

2. By affording opportunity for active participation by more individuals.

(*b*). That the structure and procedures for the foregoing purpose may be sufficiently flexible and adaptable promptly to respond to changing social, political, economic, or other conditions affecting the welfare of society and of engineers

1. To check divisive trends in the field of common professional interest.

2. To promote community of purpose and effort within the engineering profession."

OUTLINE OF EXISTING TYPES OF ORGANIZATION

A majority of engineers are members of some engineering society, institute, or club. It is clear that engineers are interested in association, in co-operation for worthy goals not open to individual action, and the number of individuals who are members of more than one society indicates a rather general desire for broader interests. But there is no one organization or leadership that can speak effectively for the profession—no one society represents even ten per cent of the total number of engineers.

With the pattern of an over-all organization or association becoming clearer, it is important that all of the members have a better picture of the present types of organization in which it is proposed to correlate and co-ordinate general professional activities. They are the foundation on which we may build a stronger structure.

There are three general types of individual member organizations—which we might designate as vertical, horizontal, and broad:

1. Societies which are primarily for advancement of the theory, practice, and allied arts of engineering in one of its branches or specialties are vertical in the sense that individual memberships are in national organizations within the special field. Local sections are formed among the members, but they are quite limited in their scope outside their technical meetings.

2. Local societies to cross all technical branches for general understanding of engineering and for fellowship purposes would be shown at right angles to the national technical society organizations. Activities may be quite broad on a local scale, and these societies have been highly successful in many cities.

3. State professional societies in a national organization (National Society of Professional Engineers) have been most actively interested in registration and in professional and public recognition. Emphasis on ethical conduct and proper practice and safeguards for individual interests have been further objectives.

There are also three general arrangements to provide co-operation on a limited scale among the member organizations:

1. Local councils of national society local sections, and in many cases including local societies, have furnished an important pattern for unification with definite purposes. Co-ordination of program activities, occasional joint meetings, and a local announcement publication are the usual objectives, with committees for civic and professional affairs included in many cases.

2. Engineers' Council for Professional Development has been the medium for contacts and co-operation among several major national technical societies, the engineering educators, and the state boards of engineering examiners. The best known accomplishments of ECPD have centered around formulation of engineering college criteria, with other developments in its program including aids for student counsel and similar helps in orientation. Primarily a conference rather than an agency for administration, its recommendations are placed in the hands of the constituent organizations for further development.

3. The Engineers' Joint Council is a voluntary association for co-ordinating purposes. Its members are the president, past president, and secretary of the American Society of Civil Engineers, AIEE, American Society of Mechanical Engineers, American Institute of Chemical Engineers, and American Institute of Mining and Metallurgical Engineers. This council meets frequently to discuss problems of common interest to engineering societies and frequently has made pronouncements on subjects of national importance affecting all engineers, particularly during the war period. This council now is engaged in a study of the economic status of engineers and a study of collective bargaining for engineers.

SURVEY OF MEMBERSHIP OPINIONS

Approach. As the first step in this study, the subcommittee prepared outlines of four possible plans for "Organization of the Engineering Profession." This preliminary report was presented at the conference on Institute activities at the winter convention in New York, N. Y., January 23, 1946. A progress report of the essentials of these plans was published (*EE, Apr '46, pp 169–73*).

A questionnaire was developed to determine individual views of the Institute members on the subject. The original form was found to include too much detail and from it was evolved a simplified questionnaire (Figure 1). A condensed outline of the four plans was used in connection with the questionnaire.

Members of the subcommittee and others have described the four possible plans orally at open meetings during the AIEE summer convention, the Pacific Coast meeting, at several District meetings and District executive committee meetings, and 17 meetings of Section members or executive committees. Following open discussion at these meetings, copies of the condensed outline and of the questionnaires were distributed, and each member present was asked to express his preferences and make such comments as he desired.

Four Plans. Details of the four plans may be stated in basic form as:

A. American Society of Electrical Engineers. Consolidation of the existing electrical engineering societies into a single organization, as an initial step toward an all-inclusive engineering society.

B. Parallel Societies. Continuation of the present technical societies for technical matters only, with all nontechnical or general activities to be carried on by a separate autonomous professional society with individual membership.

C. Federation of Societies. Extension of the local council and the ECPD plans with a top organization composed of representatives of the various societies having power to act on broad national subjects which affect all classes of engineers.

D. New Society. Incorporation of many of the existing societies into one American Society of Engineers which would act on subjects of general and professional importance, leaving technical meetings and publications in affiliated technical groups.

Summary. A continuous tabulation of replies to the questionnaire was made, and it became apparent with later returns that the percentages were falling into a definite pattern with little change except in fractional values. There is strong indication that the present sample of opinion is fairly representative of more active member thinking. The composite summary is shown in Table I, and in more detail in Figure 2.

Figure 2 shows these data also divided between registered and nonregistered status of members and among three age groups. The order of preference for the four plans was the same in all these groupings, except in the oldest age group where first choice for plan *C* was slightly higher than for plan *D*.

Table I

	First Choice, Per Cent	Second Choice, Per Cent
Plan *D*	39	19
Plan *C*	25	32
Plan *B*	15	19
Plan *A*	12	13
Unchanged	7	5
No choice	2	12
	100	100

Conclusions. The conclusions drawn from this survey are

1. Approximately 90 per cent of the AIEE members favor some change in organization of the engineering profession.

2. Plans *D*, *C*, and *B* are favored in that order, and plan *A* does not have enough support to warrant further consideration, except as it may be brought about under a broader plan.

3. Plan *D* has definite first choice support, with plan *C* leading in second choice as indicated by its second place in first choice and highest rating in second choice.

4. Plan *D* is desired as an ultimate, with modifications of plans *C* and *B* as intermediate stages in development.

Many comments indicated favor for plan *D*, and in some cases this was true where the plan was not shown as first choice. Either plan *C* or plan *B* frequently are referred to as intermediate steps required before complete unification of engineers is accomplished. These comments have such qualifications as, "ultimate goal but start with (*A*, *B*, or *C*)," "local councils could continue under *D*;" "attainment of *D* very difficult—there are ample organizations—let's make them work;" "*D* seems to be the best if practicable—otherwise *B*;" "start with *A* or *C* and end up with *D* and substitute plan *A* for AIEE."

OBJECTIVES OF OVER-ALL ORGANIZATIONS

An agreement on the objectives sought as the general goal of an over-all organization of engineers is of primary importance in plotting the course toward its realization. Our fundamental problem is to enlarge our individual and group viewpoints to include all phases of professional development. Our scope therefore must include and build from the four principal functions of engineering organization to provide the traditional opportunities and to increase their scope and value.

1. Technical Advancement. The traditional purpose of most engineering organizations is to provide a convenient path for the expeditious flow of technical information among the members and to broaden their interests. This makes possible a continuation of the individual's education in

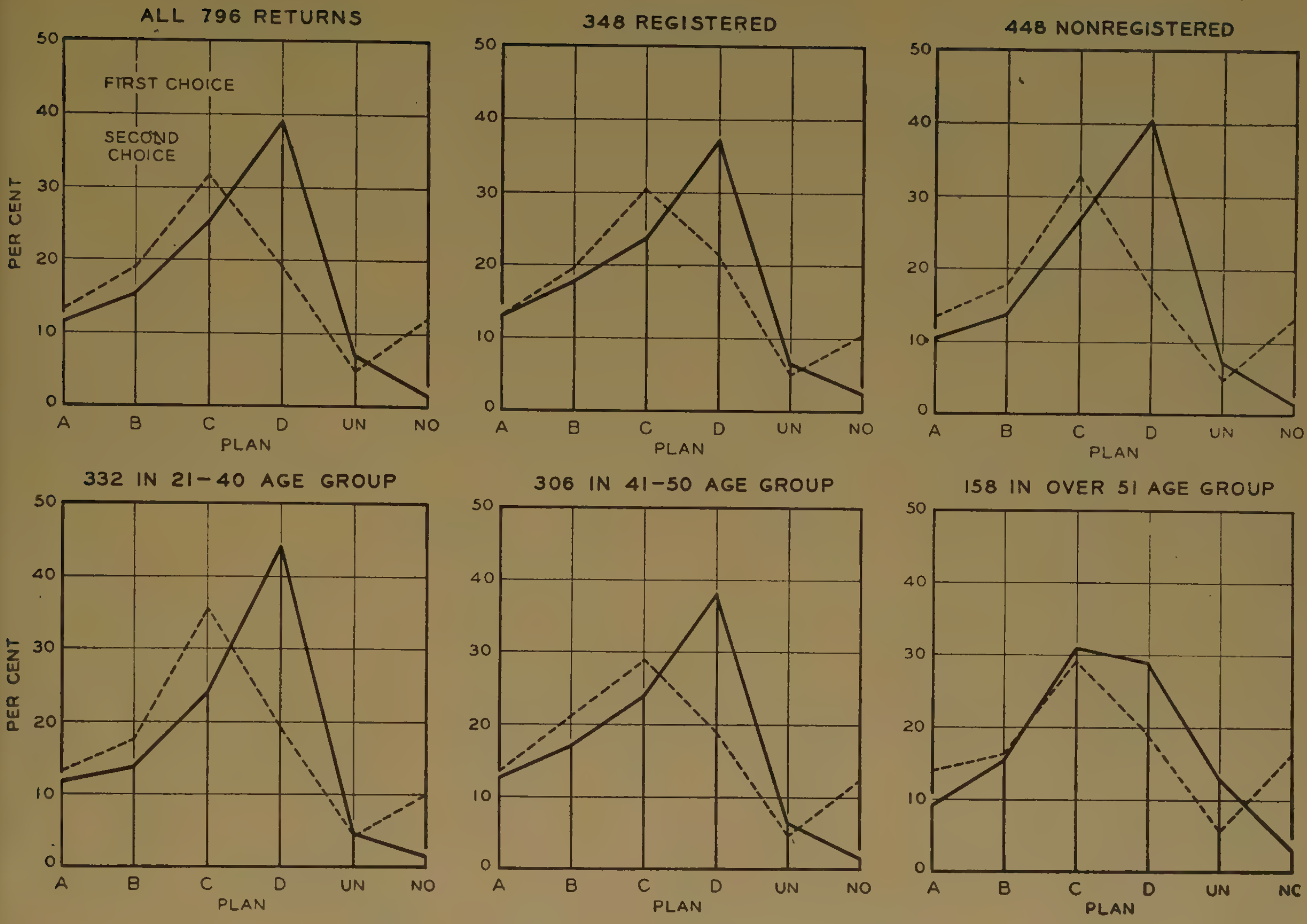

Figure 2. Summary of returns from AIEE questionnaire

796 returns; 22 meetings; June–November 1946

his chosen field and encourages interest in new developments. As individual engineers concern themselves with only one or, at most, a few of the specialized branches of engineering, it seems evident that the specialized technical division idea can not be replaced with a single group to cover all the specialties.

2. *Engineering Education.* Studies of engineering training and the development of plans for student selection and guidance are matters for joint consideration by all engineers as well as by engineers in academic life. The professors conduct the formal educational process, but practicing engineers should interest themselves in the content and standards of formal engineering education, both in the selection and guidance of suitable candidates for an engineering education and in the postgraduate training and professional development of the young engineers.

3. *Advancement of the Profession.* It is not axiomatic that a unified association of practitioners automatically will place a profession on a pedestal of dignity and prestige. But it does seem that such an association would be more successful in promoting certain objectives which generally are recognized as necessary to the maintenance of professional standards and the enhancement of public esteem. Among these objectives are a uniform code of ethics and canons of practice; a uniform definition of what constitutes full professional status; and correlation of that status with legal registration, greater uniformity among the laws of the several states affecting the practice of engineering and the licensing of engineers, standards of compensation for professional services commensurate with the value of those services, and organized assistance to individual practitioners in maintaining the dignity, integrity, and independence of the profession.

4. *Public Service.* Events of recent years have served to emphasize the important part which engineers as individuals and as organized groups can and should play in public affairs. It would seem reasonable to expect that engineers should be able to apply their talents for the effective and efficient organization of men and materials to the problem of rendering a disinterested public service as a professional group at the several levels of government. Such service should be rendered in times of peace as well as during national emergencies. Definite avenues for cooperation with government agencies should be established and used.

NECESSITY FOR NEW APPROACH

There has been an increasing amount of criticism of the engineering profession by the engineers themselves. That change in the present fragmentation of the functions of organization is in order seems clear from the results of this survey, as well as from many engineering publications. Some conclusions resulting from these comments are

1. Most engineers believe that the present organization, consisting of multitudinous societies, largely technical in purpose and with memberships almost wholly restricted to certain branches or strata of the profession, is sorely inadequate.

2. The present economic status of engineers, the aggressiveness of labor organizations, the need for an engineering approach to many of mankind's problems, and the trend to further fragmentation of organization are cited as reasons for demanding a policy of "less talk and more action."

3. There seems to be a willingness on the part of many members of engineering societies to see the present societies sacrifice their rights and prerogative to the extent necessary for unification of professional organization.

ACTION FAVORED BY INSTITUTE MEMBERSHIP

The professional activities subcommittee recommends adoption of a plan which is based on that originally proposed as plan *D*, modified with certain features from plans *B* and *C* which might add to its strength, particularly during the formative stages. In effect, this proposal would seek to co-ordinate present activities and objectives and to carry forward the purposes which have caused engineers to join together in groups in the past.

This seems quite logical as a process of evolution and growth. It has the merit of utilizing present organizations in their present, most active fields of endeavor, and it delegates to other sponsorship those activities which have not received major attention in the past. It should be realized that this program includes a considerable modification of the general committees of individual affiliated societies in the interest of unification of their purposes.

The apparent directive of a large percentage of electrical engineers, reflected in the returns on this survey, is interpreted to be

> To provide an over-all engineering organization of the individual membership type with the continuation of affiliated societies for specialized technical purposes only; with stronger emphasis on educational standards and professional advancement; with more co-operation and strengthened support at the local organization level; and with more publicity of the general interest activities of the profession.

To carry out the apparent directive from the membership and to take into account the many comments for improvements in the suggested plans, a skeleton form of constitution has been prepared for a professional society to represent all engineers. The proposed constitution is summarized in the following section of this report.

PRINCIPLES OF CONSTITUTION

In keeping with the subcommittee's goal of presenting only a skeletonized plan for over-all organization, no attempt is being made to write a formalized nor detailed constitution for the proposed American Engineering Association.* It does seem desirable, however, that the main topics of such a constitution be stated in brief to present the fundamentals of organization. The following is submitted as the basis for a constitution.

Name and Objectives. The organization should be known as "The American Engineering Association." Use of the word "American" is intended to indicate that qualified engineers anywhere in the Americas are eligible for membership.

The association's principal objectives, briefly stated, should be the maintenance of high professional standards among its members, the advancement of standards of engineering education, the enhancement of professional recognition and status, and the stimulation of engineers to take their proper place—individually and collectively—in public affairs. In addition, the association shall aid and encourage, principally through its affiliated societies, the advancement of the theory and practice of engineering in its several branches.

Membership. Membership should be open to engineers in all branches of the profession who qualify under one or more of the following grades of membership. Fellows, Members, and Associates should be entitled to all rights of membership, except that Fellows only should be eligible for the office of president and that Fellows

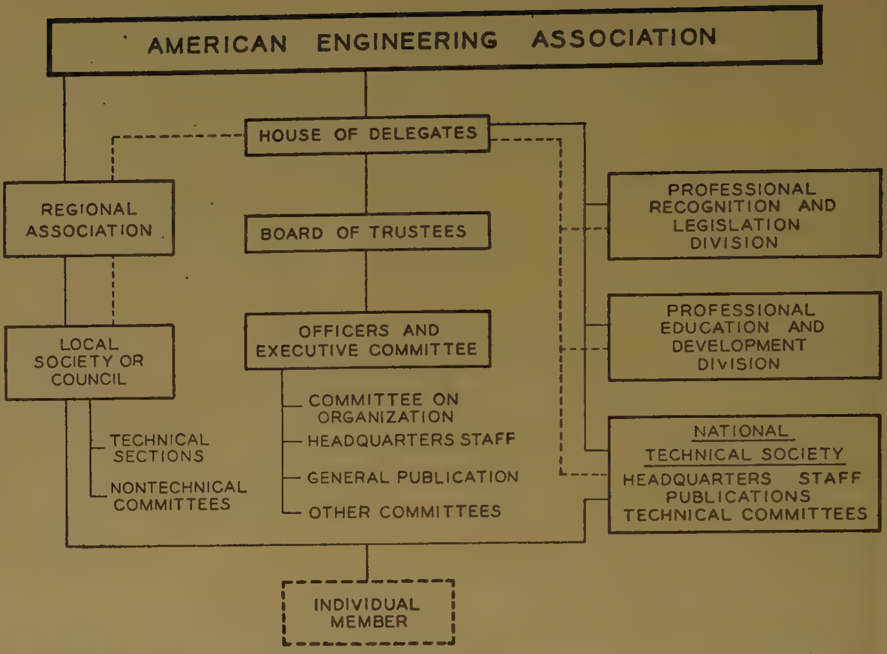

Figure 3. Organization chart of proposed American Engineering Association

———— *Membership and control* - - - - - - - *Elective representation*

and Members only should be eligible for the other elective national offices in the association. The grades and qualifications for membership should be as follows:

FELLOW

An engineer of distinction.

MEMBER

1. A person registered *by examination* under the laws of any state having minimum qualifications equivalent to 1 and 2.

2. Graduation from an approved course in engineering of four years or more in an approved school or college, and a specific record of an additional four years or more of active practice in engineering work of a character satisfactory to the examining body.

3. Eight or more years of active practice in engineering work of a character satisfactory to the examining body. Other evidence which will satisfy the examining body that the applicant has knowledge substantially equivalent to that obtained by graduation from an approved school or college.

ASSOCIATE

Minimum qualification is graduation from a 4-year engineering curriculum in an accredited school or college.

AFFILIATE

A person who is engaged in some phase of recognized engineering activity, but who cannot qualify for another grade of membership.

STUDENT

Any person registered as a student, graduate, or undergraduate in an accredited college, university, or technical school, who is pursuing a regular curriculum in preparation for the engineering profession.

Plan of Organization (Figure 3). Membership in the association would be held by individual engineers. Individual members would be encouraged to form local units and would be associated in state or regional societies, which in turn would be represented in the national association by elected delegates on a proportional basis.

National technical societies which meet appropriate requirements would be eligible to be affiliated with the association and to be represented by elected delegates on a proportional basis.

The house of delegates thus constituted would elect a smaller board of direction, including the president and other officers. Actions and policies of the house, which would meet annually, would serve to guide the board and officers in administering the association. The affiliated technical societies would elect their own officers and administer their own affairs autonomously.

Dues. The expenses of the association and of its regional and local units would be met by dues paid by individual members. These would be collected by the local or regional units of the association and the total amount divided on a proportional basis between the association's national, regional, and local treasuries. Entrance and transfer fees would be provided for if found desirable.

The affiliated national technical societies would maintain their own systems of dues, covering the special services rendered to their members.

Meetings. Meetings of members of the association would be organized by its local and regional units, but no regular national meetings designed to attract individual members would be held. This field of activity would be reserved to the affiliated technical societies.

The annual meeting of the house of delegates would be planned so that meetings of officers and committees of regional and affiliated societies could be held concurrently.

Publications. The association would publish one general interest magazine for distribution to all its members. The various affiliated technical societies would be responsible for publishing separately material in their respective specialized fields.

Elements of Final Organization. Subject to general policy control of a new house of delegates, representing all participating groups on a proportionate basis, the plan should

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* This is a type name, used to indicate the character of the proposed organization rather than as a specific recommendation.

1. Designate a division to act for the association in matters of professional registration and legislation. With the stronger voice of a majority of professional engineers it should seek, for example, revisions of national legislation to the end that engineers, as designated by registration under state laws, would be exempt from inclusion in heterogeneous labor unions.

2. Designate a division to act for the association in educational matters, to advance a uniform code of ethics, uniform grades of membership, and in other similar activities.

3. Provide a committee on organization, one function of which would be to promote adaptation of local organization plans to the pattern of the national organization. The local organizations, with their technical sections of the national technical societies, would expand the present local council and affiliation plans and represent the profession in local matters of an engineering nature. Wherever possible, local councils and local societies should be combined as individual membership organizations as a preparation for general unification.

4. Provide a general interest publication to go to all individual members, to bring together the many similar sections of present publications, and initiate a program toward unifications of publication policies.

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11. A Survey of Co-operative Councils, **Frank Sanford.** *ELECTRICAL ENGINEERING*, volume 64, August 1945, pages 296–8.

12. An Over-all Engineering Society, **A. B. Parsons.** *Mining and Metallurgy*, June 1945, page 285.

13. Organization of the Engineering Profession, **J. F. Fairman.** *ELECTRICAL ENGINEERING*, volume 64, June 1945, pagds 220–3.

14. A Unified Profession Needed, **Harold E. Wessman.** *Engineering News Record*, March 8, 1945, page 99.

Membership Badge Prices Boosted

At the last meeting of the AIEE board of directors certain increases in prices of membership badges were approved to meet increased costs. The old and new prices are listed as follows:

Badge	Old Price	New Price
Large vest pin	$4.50	$5.00
Large charm	4.50	5.00
Large lapel button	4.50	5.25
Small vest pin	3.00	3.00
Small lapel button	3.00	3.25
Small key charm	4.50	5.00

The prices include the Federal excise tax on jewelry.

STANDARDS • • •

Publications Released for Trial and Criticism

"Proposed Standard for Low-Voltage Air Circuit Breakers (AIEE *20A*)" was published by the AIEE Standards committee in December 1946 for one year trial use after preparation by a working committee of the circuit breakers and assembled switchgear subcommittee of the AIEE committee on protective devices. Chairman of the working group is J. D. Wood (M '27) of I-T-E Circuit Breaker Company, Philadelphia, Pa. This proposed standard applies to all air circuit breakers with interrupting rating over 10,000 amperes and certain other qualifications. Included in the pamphlet are standards applying to service conditions, definitions, ratings, heating, dielectric tests, and nameplate markings.

"Report on Recommended Practice for Insulation Resistance Testing of A-C Rotating Machinery (AIEE *43*)" was published for comment and criticism by the 1945–46 subcommittee on insulation resistance of the AIEE committee on electric machinery. Chairman of the subcommittee was A. M. DeBellis (M '33) of Consolidated Edison Company of New York (N. Y.), Inc. The purpose of this pamphlet is to review the factors which affect or change the insulation resistance characteristic, to outline and recommend uniform methods of making tests, and to present formulas now available for calculation.

Conference Proposed for Montreal Meeting

During the summer meeting of the Institute to be held in Montreal, Quebec, Canada, June 9–13, 1947, an all day standards conference is proposed to discuss fundamental differences between American and foreign standards practice.

In setting up this conference it has been decided to limit discussion, for the present, to switchgear, transformers, motors, and standard voltage levels. In each case papers will be presented by prominent American and foreign experts outlining essential differences in American and foreign practice with the hope that with such difference clearly defined it may be possible eventually to arrive at uniform practices in the countries concerned.

The meeting will be opened by Howard Coonley, president of the International Organization for Standardization, to be followed by brief talks by Doctor E. C. Crittenden (F '44), of the National Bureau of Standards, Washington, D. C., and past president of the United States National Committee of the International Electrotechnical Commission, and L. F. Adams (F '42) of General Electric Company, Schenectady, N. Y., now president of the committee.

SECTION • • • • • •

New York Section Adds Puerto Rico Division

The distinction of being the first geographical Section subdivision formed outside of the North American Continent goes to Mayaguez, Puerto Rico. Manuel Font (M '33), consulting engineer was instrumental in arranging for its organization on March 9, 1947. Miguel Wiewall, Jr., (M '35) was elected chairman and Modesto Iriarte was elected secretary-treasurer. Wiewall and Iriarte are both associated with the College of Agriculture and Mechanical Arts, University of Puerto Rico.

Manuel Font

The Division will embrace the districts of Aguadilla, Arecibo, Mayaguez, and Ponce. Monthly meetings will be programmed and the New York Section will give every possible support in developing its activities including close co-operation with the AIEE Student Branch at the university.

Florida Subsection Holds Edison Dinner

Kerosene lamps furnished the illumination when J. W. Butler (M '38) of General Electric Company, Schenectady, N. Y., spoke on Edison's life and achievements at a dinner held by the West Florida Subsection in commemoration of the centennial of Edison's birth

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West Texas-New Mexico Section Meets With AIME

A joint meeting of the West Texas-New Mexico Section and the El Paso Metals Section of the American Institute of Mining and Metallurgical Engineers was held on February 13 in commemoration of the 100th anniversary of Thomas A. Edison.

H. J. Kongabel (A '43), application engineer for Westinghouse Electric Corporation, El Paso, Tex., introduced the principal speaker, Doctor Phillips Thomas, research engineer for Westinghouse, who demonstrated and explained some radar and electronic equipment in his discussion, "Electronic Magic." A. A. Brown, chairman of the AIME, concluded the meeting with an expression of thanks to Doctor Thomas.

ABSTRACTS • • •

Summer Abstracts to Appear in June

Late arrival at AIEE headquarters of the majority of the abstracts of technical papers to be presented at the summer general meeting in Montreal, Québec, Canada, prohibited their publication in this issue of *ELECTRICAL ENGINEERING*. All abstracts that are available are scheduled to printed in the June issue. Subjects will be included from 18 technical groups.

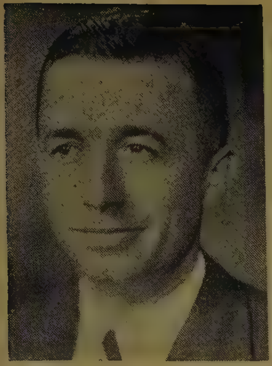
PERSONAL • • • •

Sir Standen Leonard Pearce (A '08, F '12) engineer in chief, London (England) Power Company, Ltd., recently was awarded the Faraday Medal of the Institution of Electrical Engineers for his outstanding contributions to the advancement of engineering practice and notable achievements in electrical engineering. This 25th award of the medal was the 12th to an AIEE member. Sir Leonard was born September 28, 1873, in Crewkerne, Somerset, England, and was graduated from Bishops Stortford College and Finsbury Technical College. His first positions were with J. G. Statter and Company, West Drayton, and Thomas Richardson and Sons, Hartepool. He joined the British India Steam Navigation Company in 1894 and shortly afterwards became assistant engineer to the Metropolitan Electricity Supply Company. After a period with the British Thomson-Houston Company, he became superintendent of engineering at the power station of the Central London Railway in 1900. He was appointed deputy chief electrical engineer at Manchester in 1901, and chief engineer in 1904, serving in the latter position until in 1925 he was made an Electricity Commissioner. He was appointed engineer in chief of the London Power Company in 1926. Sir Leonard again served as an Electricity Commissioner from 1940 to 1945. He is a past vice-president of the Institution of Electrical Engineers, a past president of the Junior Institution of Engineers, and is a member of the Institution of Civil Engineers and the Incorporated Municipal Electrical Association. He is the author of a number of technical papers and was Thomas Hawskley lecturer at the Institution of Mechanical Engineers in 1940.

L. O. Grondahl (A '26, M '42) director of research and engineering, Union Switch and Signal Company, Swissvale, Pa., has been awarded a George R. Henderson Medal of the Franklin Institute "in consideration of his contributions over a period of years to the development which has resulted in making available a practical system of inductive train communication." A Minnesotan by birth, Doctor Grondahl holds the degrees of bachelor of science (1904) and master of science (1908) from St. Olaf College. He received his doctor of philosophy degree from Johns Hopkins University in 1908. He was on the faculties of the University of Washington, Seattle, and Carnegie Institute of Technology, Pittsburgh, Pa., before joining the Union Switch Company in 1920. During World War II, he was a member of the National Defense Research Committee. Doctor Grondahl's work on train communication dates from 1923 and early efforts to transmit a signal through the already available medium of the train brake air line by means of sound or pressure pulses.

E. W. Boehne (A '29, F '43) formerly coordinator of research and development in the Philadelphia, Pa., works of the General Electric Company, has been appointed associate professor at Massachusetts Institute of Technology, Cambridge. Professor Boehne will be head of the Institute's co-operative course in electrical engineering. Professor Boehne, who was born in Laramie, Wyo., in 1905, received the degree of bachelor of science in 1926 and the degree of electrical engineer in 1940 from the Agricultural and Mechanical College of Texas. He also holds the degree of master of science (1928) from Massachusetts Institute of Technology. He joined the General Electric Company at Lynn, Mass., in 1927 and in 1928 was transferred to Schenectady, N. Y., where he worked on lightning and surge protection of rotating machines. In

Sir S. L. Pearce



E. W. Boehne

V. K. Zworykin

E. C. Stone

R. T. Sawyer

1933 he was transferred to Philadelphia to carry on development work on circuit breakers, for which he twice received the Charles A. Coffin Award. In 1936 he was chosen by Eta Kappa Nu as one of the five outstanding young American engineers. He was recipient of the 1944 AIEE national best paper prize in the field of theory and research. In 1943 he was awarded the best paper prize of the AIEE Philadelphia Section and in 1946 the best paper prize of AIEE District 2. At present he is vice-chairman of the AIEE Philadelphia Section. He is a member of the Franklin Institute and of the City Policy Committee of Philadelphia.

R. T. Sawyer (A '24, M '29) of the general office engineering department, American Locomotive Company, Schenectady, N. Y., has been appointed manager of the company's research department, New York, N. Y. Associated with the American Company since 1930, Mr. Sawyer has made gas turbine locomotives his specialty and recently has been concerned with the design and development of Diesel-electric locomotives. Previously he traveled the United States, Australia, and Europe as engineer on gasoline and Diesel-electric railway equipment for the General Electric Company. He is the author of "The Modern Gas Turbine" and coauthor of "Applied Atomic Power." Mr. Sawyer is chairman of the co-ordinating committee on gas turbines of the American Society of Mechanical Engineers and is a member of the Society of Automotive Engineers.

V. K. Zworykin (M '22, F '45) director of electronics research, Radio Corporation of America's Laboratories Division, Princeton, N. J., has been elected vice-president and technical consultant of the laboratories division. Doctor Zworykin also recently was awarded the Potts Medal of the Franklin Institute "in recognition of his outstanding contributions to the science and art of television, which he has advanced not only through the invention of the iconoscope in which the principle of storage and integration of image light first was employed, but also through the development of the accessory equipment including the kinescope, needed in complete commercial television." Born in Russia in 1889, Doctor Zworykin was graduated from the Petrograd Institute of Technology with the degree of electrical engineer and after graduation continued with research work at the institute. In 1912 he worked on X-ray development at the College of France, Paris. At the close of World War I, he joined the research staff of the Westinghouse Electric Corporation, East Pittsburgh, Pa., and in 1926 received the doctor of philosophy degree from the University of Pittsburgh. He joined the Radio Corporation of America in 1929 and in 1930 was named director of electronic research. He is coauthor of "Photocells and Their Application," "Television," and "Electron Optics and the Electron Microscope."

L. F. Adams (A '09, F '42) formerly manager, standards division, General Electric Company, Schenectady, N. Y., has been appointed standards consultant, and **R. C. Sogge** (M '35) assistant manager, general stations divisions since 1945, will succeed Mr. Adams as manager of the standards division. A graduate of Pennsylvania State College, Mr. Adams has been with the General Electric Company since 1906, with the exception of the years 1907 to 1909 during which he was instructor at Pennsylvania State College, State College, Pa. He was appointed manager of the standards division in 1938. Mr. Sogge, who holds the degrees of bachelor of laws from Ohio Northern University and master of laws from John Marshall School of Law, has been associated with the company since 1916. He has been connected with the transformer sales department; the Cleveland, Ohio, district office; and the central stations department.

E. C. Stone (M '19, F '31) vice-president and general manager, Duquesne Light Company, Pittsburgh, Pa., has retired. Born in New Hampshire in 1882, Mr. Stone holds the degrees of bachelor of arts (1904) and bachelor of science (1905) from Harvard University. He gained his early experience with the Westinghouse Electric Corporation, East Pittsburgh, Pa., from 1905 to 1911 as engineer on transformer design. In 1911 he was made engineer of cable operation for the Allegheny County Light Company and in 1913 system operator for the Duquesne Company. Subsequently he became assistant to the general manager in 1919, planning engineer in 1922, and system development manager in 1927. He was assistant to the president, Philadelphia Company and Subsidiary Companies, from 1931 to 1938, and in 1938 was elected vice-president and general manager of the Duquesne Company. During the years from 1925 to 1928, he taught courses on the economics of public utilities at the University of Pittsburgh and in 1927 was graduate lecturer at Yale University. He was AIEE director from 1925 to 1929 and AIEE vice-president for 1929–31.

T. H. Hogg (M '31, F '38) chairman of the Hydro-Electric Power Commission of Ontario, Toronto, since 1937, has retired but will continue as a consultant for the Commission on the proposed frequency standardization and the power developments now under construction. Born in Ontario in 1884, he received his degrees of bachelor of science and civil engineer from the University of Toronto, and in 1927 the honorary degree of doctor of engineering from the same university. He was on the engineering staff of the Ontario Power Company, Pulaski, N. Y., for one year and spent one year as editor of the *Canadian Engineer* before joining the Power Commission in 1913 as assistant hydraulic engineer. He was named chief hydraulic engineer in 1924, chief engineer in 1934, and chairman and chief engineer in 1937. He is a member of the Engineering Institute of Canada and of the American Society of Civil Engineers.

S. J. Lisberger (A '05, F '39) chief of the electric distribution division, Pacific Gas and Electric Company, San Francisco, Calif., has retired. He will continue to serve the company in a consulting capacity. Mr. Lisberger, who was born in Virginia in 1881, received from the University of Wisconsin the degrees of bachelor of science in 1903 and master of science in 1909. He first joined the Oakland (Calif.) Gas, Light, and Heat Company, predecessor of the

Pacific Company, in 1904. In 1906 he became assistant engineer for the newly organized Pacific Company in San Francisco, and in 1911 was named engineer. He was appointed chief of electrical distribution in 1921, and in that position built the company's first rural power line for agricultural service. He also was one of the originators of the plan for interconnecting all the company's electric facilities into one system. He is a member of Tau Beta Pi.

P. H. Powell (A '06, M '15) professor of electrical engineering, Canterbury College Christchurch, New Zealand, has retired. Professor Powell was born in Liverpool, England, in 1882, and attended Liverpool College and University and received the bachelor and master of sciences degrees from Victoria University. After employment as test house assistant for Siemens Brothers, Stafford, England, he was appointed to the faculty of Canterbury College in 1905 to inaugurate a course leading to the degree of bachelor of engineering. In 1922 he was appointed to the chair of electrical engineering at the college. He is a member of the Institution of Electrical Engineers and the New Zealand Institute of Engineers.

B. B. Beckett (A '04, M '23) since 1923 rate engineer, with the Pacific Gas and Electric Company, San Francisco, Calif., has retired. Mr. Beckett, who was born in Mississippi in 1881, holds the degrees of bachelor of arts (1902) from the University of Mississippi and mechanical engineer (1904) from Cornell University. He joined the Electric Storage Battery Company in Philadelphia, Pa., in 1909, later being transferred as branch manager to Seattle, Wash., and San Francisco. Except for a period with the Goldfield Consolidated Mines Company, he engaged in consulting work from 1913 until in 1923 he joined the Pacific Gas and Electric Company. He is a member of the Engineers Club of San Francisco.

W. A. Jackson (A '22, M '33) general superintendent, telephone and telegraph, New York Central System, New York, has retired. Born in Detroit, Mich., in 1876, Mr. Jackson commenced his career in the Detroit office of the Michigan Central Line of the New York Central. After filling the positions of yard clerk, telegraph operator, and train dispatcher, he was made manager of the Detroit telegraph office in 1911. He became joint superintendent of telegraph in 1931 and in 1941 was transferred to New York as general superintendent of the telegraph and telephone system.

G. O. Brown (A '15, M '44) manager of distribution, Kansas City (Mo.) Power and Light Company, has resigned from that position. Mr. Brown started work with the company as a meter tester and installer in 1912. In 1915 he was made foreman of the laboratory and, after service in World War I, returned to the company, becoming superintendent of the substation department. He was appointed assistant to the vice-president in 1933 and manager of distribution in 1943. A graduate of the University of Kansas, he is a member of the Missouri Society of Professional Engineers and the Chamber of Commerce, and is a director of the Industrial Council of Kansas City and a past president of the Electric Association of Kansas City.

Samuel Berman (A '36, M '44) associate director, Waugh Laboratories, New York, N. Y., has received the Longstreth Medal, annual award of the Franklin Institute for inventions of higher order. Mr. Berman was honored "in consideration of the development of a metal locator for use in surgery which has facilitated greatly the location and removal of foreign metallic bodies imbedded in the tissues." Born in Russia in 1895, Mr. Berman studied engineering at Cooper Union and the Polytechnic Institute of Brooklyn. He was associated with the Board of Transportation of the City of New York, N. Y., from 1931 until 1941 when he joined Waugh Laboratories.

M. F. Peters (M '44) formerly chief of research, Titeflex, Inc., Newark, N. J., has been appointed chief engineer of the company. Mr. Peters, received the degree of bachelor of science from the Michigan College of Mines in 1917, the degree of master of arts from George Washington University in 1925, and the degree of doctor of philosophy from Johns Hopkins University in 1931. After World War I he became a physicist for the National Bureau of Standards, Washington, D. C., where he remained until he joined the Titeflex company in 1943.

H. L. Logan (A '19, F '43) formerly manager of the Controlens division of the Holophane Company, Inc., New York, N. Y., has been appointed manager of the department of applied research of the company. Born in New York in 1896, Mr. Logan is a graduate of the Institute of Polytechnics, Birmingham, England. He has been with the Holophane Company since 1919. An active member of the Illuminating Engineering Society and an honorary life member of the Mexican Institute of Illumination, he has lectured on lighting to AIEE audiences throughout the United States, Canada, and Mexico.

J. H. Smith (A '42) manager of the supply department, Toronto district, Canadian General Electric Company, Ltd., has been elected second vice-president of the Association of Professional Engineers of the Province of Ontario. **G. B. Tebo** (A '36) supervising engineer, electrical section, laboratories, Hydro-Electric Power Commission of Ontario, Toronto, has been elected a councilor of the electrical branch of the association. **W. E. Ross** (M '38) manager, apparatus sales department, Canadian General Electric Company, Ltd., Toronto, has been appointed a councilor to represent the government of Ontario.

J. S. Morgan (A '39, M '46) formerly sales engineer, switchgear division, Allis-Chalmers Electric Manufacturing Company, Milwaukee, Wis., has been named engineer in charge of sales for the switchgear and control section. A 1935 graduate of Purdue University, he has been with the company since 1937. **T. G. A. Sillers** (A '26, M '43) formerly assistant engineer in charge of the switchgear division, has been appointed engineer in charge of development of the switchgear and control section. A graduate of the University of Manitoba, Mr. Sillers joined the company in 1935.

J. M. Whittenton (A '37, M '46) formerly instrument designing engineer, General Electric Company, Lynn, Mass., has been made assistant sales manager. Mr. Whittenton was graduated from North Carolina State College and joined the General Electric Company in 1929. During the war he worked with government agencies and the American Standards Association to step up requirements for instruments for wartime service.

Samuel Berman

H. L. Logan

M. F. Peters

J. W. Latham

J. J. Mellon

P. M. Ross

P. M. Ross (A '34, M '40) formerly superintendent of the high-voltage laboratory, Ohio Brass Company, Barberton, Ohio, has been transferred to Mansfield, Ohio, as consulting engineer. Mr. Ross, who was graduated from Purdue University in 1933, joined the company in 1934. He has been development engineer, engineer in charge of high-voltage testing, and, since 1937, superintendent of the high-voltage laboratory. He is a member of Eta Kappa Nu, has served on a number of AIEE subcommittees, and is the author of several papers, one of which he presented at the 1946 meeting of the International Conference on Large Electric High-Voltage Systems.

J. W. Latham (M '27) assistant to the general manager and until recently chief engineer, Chesapeake and Potomac Telephone Company of Baltimore City (Md.), has retired and will become technical adviser to the chief of the Communications Branch of the United States Military Government for Germany, Berlin. Mr. Latham received the degree of bachelor of science from the University of Virginia. His telephone career commenced in 1906, when he joined the Western Electric Company, Chicago, Ill., as draftsman. After serving with that company and the Illinois Bell Telephone Company, he was transferred in 1909 to the Southern Bell Telephone and Telegraph Company, Atlanta, Ga., as engineer's inspector. In 1920 he joined the Chesapeake and Potomac group of companies, serving as facilities engineer and later as plant extension engineer until 1929, when he was appointed chief engineer of the West Virginia Company. In 1939 he was transferred to Baltimore.

C. E. Boman (M '26) member of the technical staff, Bell Telephone Laboratories, Inc., New York, N. Y., has retired. He received the electrical engineering degree from the University of Minnesota in 1905, and, after a period with the Stromberg-Carlson Company, Rochester, N. Y., he entered the student training course of the New York Telephone Company. In 1909 he was transferred to the Western Electric Company, Hawthorne, Ill. From 1919 to 1921 he was concerned with dial system development in New York, London, England, and Antwerp, Belgium. Since 1921 he has been associated with the development of panel and number 1 crossbar switching equipment. During World War II he developed equipment for the Armed Forces.

D. D. Higgins (A '13, M '27) formerly electrical assistant to the superintendent of generating stations, Commonwealth Edison Company, Chicago, Ill., has been appointed superintendent of generating stations. A graduate of Lewis Institute of Technology, Mr. Higgins joined the utility company in 1904. He was named chief operator of substations in 1907, relief operator in 1908, and district operator in 1909. In 1921 he was appointed assistant chief engineer of the Northwest generating station, and in 1924 electrical assistant to the superintendent of generating stations.

C. G. Spencer (M '22) telephone engineer, Bell Telephone Laboratories, Inc., New York, N. Y., has retired. Mr. Spencer joined the manufacturing department of the Western Electric Company in 1899 and in 1905 was transferred to the inspection group of the engineering department. He was transferred to apparatus design work in Hawthorne, Ill., in 1911 and to the systems development department in New York, in 1914. He was sent to Sweden in 1921 and upon his return in 1923 entered the switching development department. He since has been engaged in developing all types of systems for manual central offices.

J. J. Mellon (M '45) who has been with the Allen-Bradley Company, Milwaukee, Wis., since 1945, has been appointed chief engineer of that company. A 1923 graduate of Rensselaer Polytechnic Institute, Mr. Mellon was steel mill electrical engineer with the Westinghouse Electric Corporation from 1924 to 1929. Joining the Clark Controller Company, Cleveland, Ohio, in 1929, he was first manager of the apparatus and engineering department and then assistant sales manager. He was elected president of the company in 1944. Mr. Mellon has been active on the engineering and advisory committees of the industrial control section of the National Electrical Manufacturers Association.

B. G. LeMieux (A '41) formerly plant manager, Fibre Conduit Company, Orangeburg, N. Y., has been elected a vice-president of the company. Mr. LeMieux, a graduate of the University of Vermont (1925), joined the company in 1930 as assistant plant engineer. He became manager of the underfloor duct division in 1932 and plant engineer in 1936. In 1937 he was appointed chief engineer and in 1939 director of research. He had been plant manager since 1945.

W. G. Ellis (A '23) commander, United States Naval Reserve, who was associated during the war with the Army–Navy Electronic Production Agency, Philadelphia, Pa., has been appointed manager of industrial electronic sales for the RCA Victor Division of the Radio Corporation of America. A graduate of Drexel Institute of Technology, he joined the United States Navy in 1917 and did research on radio direction finding from 1918 to 1922. He went into consulting industrial engineering in 1922 and into engineering sales of industrial equipment in 1927. He is a member of the Franklin Institute, the American Society of Mechanical Engineers, and the Institute of Radio Engineers.

R. T. Stafford (A '18, F '46) formerly manager of the transformer section of the Pittsburgh, Pa., works of the Allis-Chalmers Electrical Manufacturing Company, has been appointed assistant to the vice-president. Mr. Stafford joined the company in 1905 as a salesman and has represented the company in San Francisco, Calif.; Seattle, Wash.; Portland, Oreg.; and in Alaska. He was made assistant manager of the electrical department in 1928 and manager of the transformer section in 1943. He is chairman of the transformer section of the National Electrical Manufacturers Association.

W. A. Giger (A '41) formerly chief engineer in the railway locomotive division, Brown-Boveri and Company, Baden, Switzerland, has rejoined the Allis-Chalmers Manufacturing Company, Milwaukee, Wis., with which he was associated from 1931 to 1937, and has been placed in charge of promoting the firm's interests in the transportation industry. Mr. Giger is a graduate of the Institute of Technology, Zurich, Switzerland, and also has been associated with the Oerlikon Company in Zurich.

F. R. Groch (A '37, M '46) assistant to the vice-president, Portland (Oreg.) General Electric Company since 1940, has been appointed assistant to the vice-president, Bingham Pump Company, Portland. A 1930 graduate of the California Institute of Technology, Mr. Groch was associated with the Pacific Gas and Electric Company, San Francisco, until 1934. He then served as chief engineer of the Wesix Electric Heater Company, San Francisco, and in 1939 became assistant to the substation and generation engineer, Imperial (Calif.) Irrigation District. He is a member of Tau Beta Pi.

W. F. Cotter (A '20, M '28) formerly chief radio engineer, Stromberg-Carlson Company, Rochester, N. Y., has been appointed chief engineer for the Scott Radio Laboratories, Inc., Chicago, Ill. Previously Mr. Cotter had been associated with the American Bosch Magneto Company, Springfield, Mass., and the Federal Telephone Manufacturing Corporation, Buffalo, N. Y.

F. A. Graham (M '30) manager of power sales, Kansas City (Mo.) Power and Light Company, has retired. He was born in Maxson, Kans., in 1885, and was graduated from Armour Institute of Technology in 1912. He joined the Kansas City Company in 1913 to work on the design and installation of substations and in 1918 was appointed superintendent of power sales.

J. W. Danser (A '43) formerly of the engineering department, Consolidated Edison Company of New York (N. Y.), Inc., has joined the operation and engineering department, American Telephone and Telegraph Company, New York, to work on wire transposition problems. A 1941 graduate of Union College, Mr. Danser served in the European and Pacific theaters during the war as a lieutenant in the engineering services of the United States Navy.

H. A. Lott (A '37, M '46) who has been operating engineer of the Southern California Edison Company, Ltd., Los Angeles, since 1937, has been appointed chief of the division of electrical engineering. After being graduated from Ohio State University in 1921, Mr. Lott joined the Southern California Company in 1926 as substation operator.

C. E. Baugh (M '30) formerly assistant engineer, Pacific Gas and Electric Company, San Diego, Calif., has been made chief of the company's electrical distribution division, San Francisco, Calif. Born 1894 in Truckee, Calif., he was graduated from the University of California in 1915 and joined the company that same year.

F. L. Magee (A '20) general production manager, Aluminum Company of America, Pittsburgh, Pa., has been named a vice-president of the company. With the company since 1917, Mr. Magee was concerned with sales until 1937, at which time he was transferred from the managership of the Atlanta, Ga., office to Pittsburgh as manager of sheet sales. In 1943 he became general production manager.

C. C. Garrard (A '06) formerly head of the switch and transformer works, General Electric Company, Ltd., Birmingham, England, has been appointed resident director at the Witton works in Birmingham.

E. J. Burger (M' 42) vice-president and division manager, Ohio Public Service Company, Lorain, is now in Japan with a group of power experts who are advising General Douglas MacArthur.

H. L. Andres (A '16, M '26) vice-president in charge of the appliance and merchandise department, General Electric Company, Bridgeport, Conn., is a member of the board of governors of the Building Officials Foundation.

F. W. Knoeppel (M '44) formerly electrical engineer, United States Naval Air Station, Richmond, Fla., has joined the Walker Electrical Company, Atlanta, Ga., as sales engineer for the state of Florida with headquarters in Miami, Fla.

F. H. Murphy (A '07, F '30) formerly consulting engineer, Portland (Oreg.) General Electric Company, has retired from that position to found an independent consulting engineering firm.

E. W. O'Brien (M '37) vice-president and managing director, W. R. C. Smith Publishing Company, Atlanta, Ga., has been elected an honorary member of the Georgia Engineering Society.

Henry Waldinger (A '19, M '28) engineer and inspector, building department, Town of Hempstead, N. Y., has been elected mayor of the village of Valley Stream, N. Y.

R. A. Mulholland (A '45) formerly consulting engineer, Austin Engineering Company, Austin, Tex., has been appointed chief rate engineer for the Texas State Board of Control, Austin.

W. C. Champe (A '25, M '35) formerly of the engineering department, Electric Auto-Lite Company, Toledo, Ohio, is now with the Toledo Edison Company.

R. A. Mulholland

C. C. Brumleve (A '42) assistant to the vice-president, Thermex division, Gridler Corporation, Louisville, Ky., has resigned that position to become a manufacturers' representative in Louisville.

C. P. Potter (A '19, F '29) formerly manager, large motor engineering division, Wagner Electric Corporation, St. Louis, Mo., is now chief engineer of the company. He joined the Wagner Corporation as a student apprentice after he was graduated from the University of Illinois in 1909. He since has held the positions of foreman of transformer tests, transformer engineer, instrument engineer, and engineer in charge of the transformer department.

H. L. Deloney (M '45) transmission and distribution engineer, Louisiana Power and Light Company, New Orleans, has been appointed assistant to the vice-president and chief engineer. Mr. Deloney, who was graduated from Louisiana Polytechnic Institute in 1931, has been with the company since. He previously held the positions of division electrical engineer and state meter supervisor. In 1941 he was appointed transmission and distribution engineer.

H. H. Plank (A '41) formerly assistant general manager, Delaware Power and Light Company, Wilmington, has been appointed a vice-president of the company. Mr. Plank was graduated from Clarkson College in 1917 and saw service in World War I. He was associated with the United Gas Improvement Company in Syracuse, N. Y., and Philadelphia, Pa., from 1920 to 1943, having been made assistant to the vice-president in charge of electric sales in 1940. He joined the Delaware Company in 1943 and was made assistant general manager in 1944.

A. L. Guess (A '45) formerly draftsman, Canadian General Electric Company, Ltd., Toronto, Ontario, has joined the transformer engineering department of the English Electric Company of Canada, St. Catharines, Ontario. Previously Mr. Guess has been associated with Canadian Line Materials, Ltd., the International Resistance Company of Canada, and the Canadian Controllers Division of Railway and Power Engineering Corporation.

E. R. McKee (A '30, M '36) professor and head of the department of electrical engineering, University of Vermont, Burlington, and acting dean of the college of engineering, has been named dean of the new college of technology at the university. Professor McKee has been a member of the faculty since 1934. Previously he had been instructor and associate professor at Iowa State College, Ames, from 1921 to 1934.

P. B. Juhnke (M '20, F '36) chief operating engineer,. Commonwealth Edison Company, Chicago, Ill., has retired. Mr. Juhnke, who was graduated from Lewis Institute of Technology in 1903, joined the Commonwealth Company as an electrician's helper in 1903. He was made chief load dispatcher in 1912, assistant chief operating engineer in 1942, and chief operating engineer in 1943. He is a member of the Western Society of Engineers.

H. R. Huntley (A '23, M '29) formerly engineer in charge of the electrical co-ordination group, American Telephone and Telegraph Company, New York, N. Y., has been placed in charge of the toll group. **T. A. Taylor** (A '30, M '36) formerly engineer in the exchange and special services group, has been placed in charge of the electrical co-ordination group.

Rudolf Dueland (A '27, M '37) electrical engineer, Ebasco International Corporation, New York, N. Y., has been awarded the King Haakon VII Liberty Cross. He was cited "for outstanding services rendered Norway during the war." Mr. Dueland was chairman of the electrotechnical subcommittee of the Advisory Committee on Industry to the Royal Norwegian Ministry of Supply and Reconstruction.

H. E. Beane (A '21, M '28) formerly sales manager, The Bristol Company, Waterbury, Conn., has been appointed general sales manager for the company. Mr. Beane became a sales engineer for the company in 1920 and from 1925 to 1935 served as district manager in various branch offices. He was made field sales manager in 1936 and sales manager in 1943.

R. E. Doherty (A '16, F '39) president, Carnegie Institute of Technology, Pittsburgh, Pa., is one of five American engineers invited to London, England, by the Institution of Mechanical Engineers to speak during the celebration of its 100th anniversary in June 1947. He is the only American who will participate in a discussion of educational methods.

C. G. Sorflaten (A '40) recently released from active duty with the United States Naval Reserve, has been appointed product design engineer with the Jasper Blackburn Products Corporation, St. Louis, Mo. Mr. Sorflaten previously was distribution design engineer with the Commonwealth Edison Company, Chicago.

W. R. G. Baker (A '19, M '41) vice-president, General Electric Company, Syracuse, N. Y., has received the Army Certificate of Appreciation for "patriotic services in a position of trust and responsibility . . . for outstanding contribution to the war effort by the development, design, and production of complex Signal Corps radio and radar equipment."

Robert Soutter (A '32) manager of the Washington, D. C., office of The Okonite Company, has been granted a leave of absence. **W. R. Van Steenburgh** (A '21) manager of the light and power department, of the company's New York, N. Y., office, also has been appointed manager of the New York territory.

George Brunzell (A '40) formerly assistant plant superintendent, Washington Water Power Company, Spokane, has been appointed superintendent of plant. Mr. Brunzell entered the employ of the company in 1938 and became assistant superintendent in 1943.

A. E. Gerbore (A '43) has returned to Bell Telephone Laboratories, Inc., New York, N. Y., after serving as a *B-29* navigator for 13 months on Okinawa. He also served as communications officer in charge of a telephone exchange with the Eighth Air Force.

Vannevar Bush (A '15, F '24) president, Carnegie Institution of Washington, Washington, D. C., and chairman of the Joint Research and Development Board of the War and Navy Departments, has been elected a member of the board of directors of the American Telephone and Telegraph Company, New York, N. Y.

K. E. Gould (A '36) who has been chief, Research Branch, Civil Communications Section, Tokyo, Japan, is returning to Bell Telephone Laboratories, Inc., New York, N. Y., where he formerly was a member of the transmission development department.

J. H. Ahrens (A '44) formerly electrical engineer, distribution department, Hartford (Conn.) Electric Light Company, has been appointed safety engineer for the company.

E. O. Shreve (A '05) vice-president, General Electric Company, Schenectady, N. Y., has been appointed chairman of the National Adequate Wiring Bureau's executive committee.

OBITUARY • • • •

Albert Algernon Atkinson (A '07, M '27) dean emeritus, of the college of applied science, Ohio University, Athens, died January 20, 1947. Born March 7, 1867, in Nelsonville, Ohio, he received the degrees of bachelor of science and master of science from Ohio University. He commenced his teaching career as superintendent of the consolidated schools of East Townsend Huron County, Ohio, in 1891 and 1892. He was appointed to the faculty of Ohio University as associate professor in 1893 and was named professor in 1895. In 1936 he was appointed dean. Professor Atkinson was the author of "Electric and Magnetic Calculations," "Laboratory Manual of Elementary Physics," and "Physics of Common Things." He was a member of the Ohio Academy of Science, the American Association for the Advancement of Science, the American Society for Engineering Education, and Phi Beta Kappa.

Walter Weatherby Truran (A '23, M '30) assistant vice-president in charge of staff plant and engineering matters, American Telephone and Telegraph Company, New York, N. Y., died March 7, 1947. Mr. Truran, who was born in Milbank, S. Dak., May 25, 1894, was graduated from the University of Wisconsin in 1917 and soon after entered the employe of the New York Telephone Company, New York. In 1925 he was placed in charge of toll fundamental plans. Appointed general toll engineer in 1928, Mr. Truran was named chief engineer for the Long Island territory in 1940, and later chief engineer for the Manhattan area. He was made assistant vice-president of the American Company in 1942. He belonged to Tau Beta Pi.

Paul B. Hull (A '39) assistant superintendent of electric distribution, Public Service Company of Colorado, Denver, died January 5, 1947. Mr. Hull was born July 19, 1887, in Toronto, Ohio, and attended the University of Denver. After performing chiefly clerical work in the engineering office of the Denver (Colo.) Gas and Electric Company from 1905 to 1917, he became bench chemist for the Great Western Sugar Company, Fort Collins, Colo., and in 1918 was made foreman for the Western Chemical Company, Denver. He returned to the Great Western Company as assistant chemist in 1919. In 1922 he entered the electric meter shop of the Public Service Company, for one year, then spent four years in the electric engineering department, and in 1927 was made district superintendent at Sterling, Colo. He was superintendent at Boulder, Colo., from 1928 to 1931 and then was given charge of the distribution engineering office. He was appointed assistant superintendent of electric distribution in 1937.

Heber Eugene Plank (A '13, M '28) manager of the Seattle, Wash., office of the General Electric Company, died January 10, 1947. Mr. Plank, who was born in Morgantown, Pa., February 4, 1884, was graduated from Pennsylvania State College in 1905. He immediately joined the General Electric Company and in 1910 was transferred to the Portland, Oreg., office as turbine salesman. He was assigned to Seattle in 1913 and made manager in 1922. Mr. Plank was a member of the Seattle Chamber of Commerce and the Electric Club of Washington.

Samuel Hope Richards (M '39) chief meter examiner, Electricity Commission, London, England, died January 9, 1947. Mr. Richards was born in Bangalore, India, January 21, 1883, and was graduated from Chelsea Polytechnic Institute in London.

He entered the standardizing laboratory of the Board of Trade, London, in 1902, and in 1907 was appointed testing superintendent to the Calcutta (India) Electric supply Corporation. He joined Ferranti, Ltd., Hollinwood, Lancashire, as publicity manager in 1919. After three years with the British Electrical and Allied Industries Research Association, London, he became manager of the Southern Electric Corporation, Ltd., Chesane, Buckinghamshire, in 1933. In 1937 he joined the Electricity Commission. He was a member of the Institution of Electrical Engineers.

MEMBERSHIP • •

Recommended for Transfer

The board of examiners, at its meeting of March 20, 1947, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the secretary of the Institute.

To Grade of Fellow

Baker, W. R. C., vice-pres. electronics dept., General Elec. Co., Syracuse, N. Y.
Cisler, W. L., chief engineer of power plants, The Detroit Edison Co., Detroit, Mich.
Dissmeyer, E. F., engineer, Commonwealth & Southern Corp., Jackson, Mich.
Reynolds, B. R., supt. of power generation, New York City Transit System, New York, N. Y.
Riddle, F. H., vice-pres. & factory manager, Champion Spark Plug Co., ceramic div., Detroit, Mich.

5 to grade of Fellow

To Grade of Member

Arnett, H. E., asst. engineer, Portland General Elec. Co., Portland, Oreg.
Baxandall, F. M., asst. chief engineer, The Dow Chemical Co., Midland, Mich.
Bechtol, P. S., electrical engineer, B. F. Goodrich Co., Akron, Ohio.
Evans, H., engineer, Delaware Power & Light Co., Wilmington, Del.
Evans, T. W., research engineer, seismograph dept., Sun Oil Co., Beaumont, Tex.
Finnell, R. D., supt. Ripley S. E. station, Kansas Gas & Elec. Co., Wichita, Kans.
Gardner, E. M., 2600 Fulton St., Berkeley, Calif.
Granbois, K. J., test engineer, Safe Harbor Water Power Corp., Conestoga, Pa.
Grimshaw, C., design engineer, General Elec. Co., Schenectady, N. Y.
Hansson, B. O. N., technical manager, Liljeholmens Kabelfabrik, Stockholm, Sweden.
Hoover, W. G., associate professor of elec. engg., Stanford University, Palo Alto, Calif.
Horne, M. R., vice-pres., George R. Horne & Co., Dearborn, Mich.
Jones, J. A., supt. transmissions, Carolina Power & Light Co., Raleigh, N. C.
Jorgenson, L. M., teaching elec. engg., Kansas State College, Manhattan, Kans.
Knecht, W. G., supervising engineer, underground section, engg. dept., Commonwealth Edison Co., Chicago, Ill.
Locher, H. H., electrical engineer, Consumers Power Co., Jackson, Mich.
MacKichan, K. B., asst. prof., Duke University, Durham, N. C.
Merker, H. M., research engineer, Henry J. Morton Associates, Inc., Detroit, Mich.
Purrington, T. U., electrical engineer, Western Elec. Co., Kearny, N. J.
Rodgers, L. M., project engineer, Philco Corp., Philadelphia, Pa.
Rothe, F. S., application engineer, central sta. engg. div., General Elec. Co., Schenectady, N. Y.
Schemm, C. W., chief electrical engineer, Sverdrup & Parcel, C. E., St. Louis, Mo.
Shaffer, L. J., plant training supervisor, Ohio Bell Tel. Co., Cleveland, Ohio.
Smith, S. S., Jr., division engineer, Duquesne Lt. Co., Pittsburgh, Pa.
Tarwater, C. E., supt. of power, Knoxville Utilities Board, Knoxville, Tenn.
Thompson, B. F., industrial engineer, Public Service Co. of Oklahoma, Tulsa, Okla.
Williams, W. J., supervising service engineer, Westinghouse Elec. Corp., Seattle, Wash.

27 to grade of Member

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Any member objecting to the election of any of these candidates should so inform the secretary before May 21, 1947, or July 21, 1947, if the applicant resides outside of the United States or Canada.

To Grade of Fellow

Mittelmann, E., Illinois Tool Works, Chicago, Ill.

1 to grade of Fellow

To Grade of Member

Beattie, A. E., Gulf States Utilities Co., Beaumont, Tex.
Beegle, D. H., Naval Ordnance Lab., Washington, D. C.
Bisset, G., Potomac Elec. Pr. Co., Washington, D. C.
Byloff, C. W., New York Tel. Co., Brooklyn, N. Y.
Clarke, R. C., Walter Clarke & Sons, Ltd., London, England.
Compton, G. W., The Dow Chemical Co., Freeport, Tex.
Cook, G. W., David Taylor Model Basin, USN, Washington, D. C.
Deller, R. A., Bell Tel. Labs., Inc., New York, N. Y.
Dietze, I. C., Dept. of Water & Pr., Los Angeles, Calif.
Duff, J. E., The Hoover Co., N. Canton, Ohio.
Giare, K. L., The National Electrical Mfg. Co. Ltd., Patiala, Punjab, India.
Gould, M. E., 324 Union Bldg., 441 So. Salina St., Syracuse, N. Y.
Hammarlund, P. E., ASEA Electric, Ltd., London, England.
Hardie, L. C., Manufacturers' Representative, P. O. Box 1491, Des Moines, Iowa.
Hart, D. C., 4528 Hamilton Ave., Cincinnati, Ohio.
Homji, B. F. M., Govt. of India, Ordnance Factory, Ambernath, India.
Jagtiani, H. N., Office of Elec. Advisor to Govt., Karachi, India.
James, N. W., Libbey-Owens-Ford Glass Co., Toledo, Ohio.
Kalyanakrishnan, A. P., Technical College, Kualalumpur, Malaya, India.
Kaspari, J. I., Ebasco Services, Inc., New York, N. Y.
Keiffer, M. H , 110 South Main St., Manheim, Pa.
Kloos, G., Philips Export Corp., New York, N. Y.
Kricker, R., Electric Indicator Co., Glenbrook, Conn.
Langdon, J. R., Jr., Langdon & Matule, Inc., New York, N. Y.
Lex, C. H., General Elec. Co., Chicago, Ill.
Mangan, R. K., Pr. Installation Co., Pittston, Pa.
Matule, J. F., Langdon & Matule, Inc., New York, N. Y.
Michaelson, J. L., General Elec. Co., Schenectady, N. Y.
Moon, C., Natl. Bureau of Standards, Washington, D. C.
Omeltchouck, B. S., The French Tramway & Pr. Co., Shanghai, China.
Redding, J. M., New Brunswick Pr. Co., St. John, New Brunswick, Canada.
Rhael, R. J., N. Y. Naval Shipyard, Brooklyn, N. Y.
Smith, E. R., Commonwealth Edison Co., Chicago, Ill.
Stark, E. M., The Austin Co., Cleveland, Ohio.
Stewart, E. Y., General Elec. Co., Schenectady, N. Y.
Strauss, F., Stone & Webster Engg. Corp., Vernon, Calif.
Sud, J. S., The Harcourt Butler School, Simla, India.
Thach, R. E., Westinghouse Elec. Corp., St. Louis, Mo.
Tobias, C. A., Univ. of Calif., Berkeley, Calif.
Trevelyan, H. B., Bell Tel. Co. of Canada, Montreal, Quebec, Canada.
Trevitt, J. H., Dictaphone Corp., Bridgeport, Conn.
Vermillion, L. S., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Watling, R. G., Bell Tel. Labs., Inc., Murray Hill, N. J.
Webber, C. A., Bell Tel. Labs., Inc., New York, N. Y.
Weeks, G. E., Western Elec. Co., Inc., Chicago, Ill.
Whelen, M. P., Toronto Hydro, Toronto, Ontario, Canada.
Zelley, W. E., John A. Roebling's Sons Co., Roebling, N. J.

47 to grade of Member

To Grade of Associate

United States, Canada, and Mexico

1. North Eastern

Birtwell, W. C., Rhode Island State College, Kingston, R. I.
Briozzo, O. L., General Elec. Co., Schenectady, N. Y.
Brumbaugh, C. J., N. Y. Tel. Co., Buffalo, N. Y.
Chapman, D. A., General Elec. Co., Lynn, Mass.
Comstock, M. E., Wagner Elec. Corp., Boston, Mass.
Cook, A. C. General Elec. Co., Schenectady, N. Y.
Dawson, D. F., N. Y. State Agri. & Tech. Inst., Alfred, N. Y.
Donivan, H. C., General Elec. Co., Schenectady, N. Y.
Fairhurst, G. F., Naval Trng Station, Newport, R I.
Fogel, C. M., Univ. of Buffalo, Buffalo, N. Y.
Forry, S. H., General Elec. Co., Schenectady, N. Y.
Fribance, A. E., Rochester Inst. of Tech., Rochester, N. Y.
Good, A. E., General Elec. Co., Schenectady, N. Y.
Grobel, L. P., General Elec. Co., Schenectady, N. Y.
Henrich, W. H., Remington Rand, Inc., South Norwalk, Conn.
Hoffer, A. H., General Elec. Co., Schenectady, N. Y.
Keller, A. L., Mass. Inst. of Tech., Cambridge, Mass.
Kettenring, W. R., Jr., General Elec. Co., Schenectady, N. Y.
Klass, P. J., General Elec. Co., Schenectady, N. Y.
Kronacher, G. G., General Elec. Co., Schenectady, N. Y.
Lynch, C. F., IBM Corp., Endicott, N. Y.
Miller, C. W., Taylor Instrument Cos., Rochester, N. Y.
Miller, G. L., Union College, Schenectady, N. Y.
Nelson, E. H., Connecticut Pr. Co., Middletown, Conn.
Parkes, R. M., Westinghouse Elec. Corp., Hyde Park, Mass.
Ramer, L. A., Marco Industries, Inc., Depew, N. Y.
Reid, E. P., General Elec. Co., Schenectady, N. Y.
Renner, J. H., N. Y. State Agr. & Tech. Inst., Alfred, N. Y.
Robbins, L. W., General Elec. Co., Schenectady, N. Y.
Rogers, G. L., General Elec. Co., Schenectady, N. Y.
Schiavoni, W., New England Tel. & Tel., Providence, R. I.
Stolaroff, M., Mu-Switch Corp., Canton, Mass.
Tamis, G. A., Champion Lamp Works, Lynn, Mass.
Taylor, R. S., General Elec. Co., Schenectady, N. Y.
Vaughan, K. A., Gould Storage Battery Corp., Depew, N. Y.
Wilson, R. C., General Elec. Co., Schenectady, N. Y.

2. Middle Eastern

Baker, G. M., Chesapeake & Potomac Tel. Co., Baltimore, Md.
Becker, H. A., (re-election), The Ohio Pr. Co., Canton, Ohio.
Bruch, D. W., American Tel. & Tel. Co., Pittsburgh, Pa.
Bruscia, P. A., Bok Vocational School, Philadelphia, Pa.
Burdette, J. C., Jr., Kelly-Springfield Tire Co., Cumberland, Md.
Caldwell, D. H., Potomac Elec. Pr. Co., Washington, D. C.
Charles, H. E., Hazard Insulated Wire Works, Wilkes-Barre, Pa.
Dolan, R. P., Jr., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Eichmuller, A. J., New York Central R. R., Cleveland, Ohio.
Flannery, J. E., Cutting & Ciresi, Cleveland, Ohio.
Geiger, L. F., Metropolitan Edison Co., Reading, Pa.
Goodman, J., Bernard Construction Co., Inc., Philadelphia, Pa.
Haining, L. E., Radio Corp. of America, Camden, N. J.
Hansen, C., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Hart, E. R., Picker X-Ray Corp., Cleveland, Ohio.
Hartman, A. E., Case School of Applied Science, Cleveland, Ohio.
Hedderson, G. W., The Elec. Storage Battery Co., Philadelphia, Pa.
Hellman, K., North Elec. Mfg. Co., Galion, Ohio.
Hoffman, T. J., Timken Roller Bearing Co., Canton, Ohio.
Hrovath, J. W., Aluminum Co. of America, Cleveland, Ohio.
Jordan, A. B., Natl. Bureau of Standards, Washington, D. C.
Kambitsch, H. J., Delco Products Div., Dayton, Ohio.
Lay, C. N., Wm. S. Scull Co., Camden, N. J.
Mathias, G. E., Westinghouse Elec. Corp., East Pittsburgh, Pa.
McClure, F. N., Westinghouse Elec. Corp. East Pittsburgh, Pa.
Mershon, C. L., Westinghouse Elec. Corp., Lima, Ohio.
Middleton, M., Jr., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Mitchell, J. W., Ohio Pr. Co., Canton, Ohio.
Nash, B. R. L., Jr., I-T-E Circuit Breaker Co., Philadelphia, Pa.
Newman, E. I., The H. K. Ferguson Co., Cleveland, Ohio.
Norris, J. W., General Elec. Co., Erie, Pa.
Pettibone, G. E., Natl. Bureau of Standards, Washington, D. C.
Pfaff, R. W., Reliance Elec. & Engg. Co., Cleveland, Ohio.
Phillips, D. P., E. I. du Pont de Nemours & Co., Henry Clay, Del.
Progler, H. S. III, Westinghouse Elec. Corp., East Pittsburgh, Pa.
Ray, R. N., Chesapeake & Potomac Tel. Co., Washington, D. C.
Richards, E. E., Ohio Brass Co., Mansfield, Ohio.
Risley, R. S., A. M. C., Wright Field, Dayton, Ohio.
Rizvi, S. I. H., Johns Hopkins Univ., Baltimore, Md.
Schneider, P., The Ohio Bell Tel. Co., Cleveland, Ohio.
Rogers, A. L., Jr., Philco Corp., Philadelphia, Pa.
Schunemann, C. F., Case School of Applied Science, Cleveland, Ohio.
Shumate, W., A. M. C., Wright Field, Dayton, Ohio.
Smith, R. W., Metropolitan Edison Co., Reading, Pa.
Smith, T. C., Youngstown College, Youngstown, Ohio.
Stanton, J. S., Jr., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Stoltz, R. D., RFD One, Fayette, Ohio.

Taylor, H. M., Jr., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Tippins, G. W., Tippins Machinery Co., Pittsburgh, Pa.
Tunell, R. H., (re-election), Union Switch & Signal Co., Swissvale, Pa.
Umbach, L. A., Jr., Aero-Rad Corp., Youngstown, Ohio.
Unland, H. L., Jr., United Engrs. & Constructors, Inc., Philadelphia, Pa.
Weaver, F. D., Natl. Bureau of Standards, Washington, D. C.
Wiggins, D. L., Superior Switchboard & Devices Co., Canton, Ohio.
Zajac, T. S., Hall, Turpin & Wachter, Baltimore, Md.
Zinn, T. L., Standard Elec. Products, Dayton, Ohio.

3. New York City

Baldson, E. J., N. Y. Tel. Co., New York, N. Y.
Beatty, E. H., Pennsylvania R. R., New York, N. Y.
Behr, S. H., N. Y. Naval Shipyard, Brooklyn, N. Y.
Bergman, B. W., North American Philips Co., Mt. Vernon, N. Y.
Black, P. B., Sylvania Elec. Products, Inc., Flushing, N. Y.
Bullwinkel, G. L., RCA Communications, New York, N. Y.
Burroughs, F. L., Sylvania Elec. Products Inc., Flushing, N. Y.
Cammarata, J., Arma Corp., Brooklyn, N. Y.
Cancilla, N. J., Audio Productions, Inc., New York, N. Y.
Corl, J. L., Sylvania Elec. Products, Inc., Flushing, N. Y.
Deiss, E. W., Federal Tel. & Radio Corp., Newark, N. J.
Diemer, F. P., Celanese Corp., Newark, N. J.
Eason, R., 1663 Walton Ave., New York, N. Y.
Everitt, W. H., Curtiss Propeller Div., Caldwell, N. J.
Fellenzer, A. D., Jr., Rockland Lt. & Pr., Middletown, N. Y.
Harris, J. R., Art Color Printing Co., Dunellen, N. J.
Hurst, O. H., General Elec. Co., New York, N. Y.
Ivins, C. F., Jr., Public Service Elec. & Gas Co., Newark, N. J.
Johns, C. N., Hdqtrs. Kassel Military Community, APO 171, c/o Postmaster, New York, N. Y.
Kardasen, G., Jr., Dumont Lab., Clifton, N. J.
Lutz, W. E., Transportation Corps Board, U. S. Army, NYPE, Brooklyn, N. Y.
Lynch, W. B., Jr., Westinghouse Elec. Corp., Newark, N. J.
MacIndoe, R. C., Westinghouse Elec. Corp., Newark, N. J.
Masucci, C., Western Elec. Co., Inc., Newark, N. J.
McKeever, W. W., Phelps Dodge Copper Products Corp., New York, N. Y.
Parris, C. A., 68 E. 90th Street, New York, N. Y.
Peters, W. R., Jr., Central Hudson Gas & Elec. Corp., Poughkeepsie, N. Y.
Pihlman, A. A., Consolidated Edsion Co. of N. Y., Inc., New York, N. Y.
Poarch, C. K., Edison Elec. Inst., New York, N. Y.
Re, J. J., Selenium Rectifier Div. of Federal Tel. & Radio Corp., Newark, N. J.
Rubel, A. A., Baker & Spencer, Inc., New York, N. Y.
Samkoff, J. S., Consolidated Edison Co. of N. Y., Astoria, N. Y.
Sander, L. A., P. J. O'Rourke Elec. Engg. Co., Inc., Brooklyn, N. Y.
Symonds, H. W., Sperry Gyroscope Co., Inc., Great Neck, N. Y.
Tacouni, M., 2020 Grand Avenue, Bronx, N. Y.
Ursitti, F. L., RCA Communications, Inc., New York, N. Y.
Vaccaro, P., Federal Tel. & Radio Corp., Newark, N. J.
Warner, R. E., Westinghouse Elec. Corp., Bloomfield, N. J.

4. Southern

Adams, F. R., Southern Bell Tel. & Tel. Co., Baton Rouge, La.
Gaston, M. H., Southern Bell Tel. & Tel. Co., New Orleans, La.
Graves, G. B., NACA, Langley Field, Va.
House, C. Y., Jr., Westinghouse Elec. Corp., Charleston, S. C.
Kaisner, R. W., N.A.C.A., Langley Field, Va.
LeDoux, J. M., National Elec. Products Corp., New Orleans, La.
McKenzie, M. T. (re-election), Savannah Elec. & Pr. Co., Savannah, Ga.
Morris, R. E., Allis-Chalmers Mfg. Co., Charlotte, N. C.
Nelms, M. H., Alabama Pr. Co., Birmingham, Ala.
Pogue, P. C., Alabama Pr. Co., Birmingham, Ala.
Ringger, W. A., Jr., Memphis Lt., Gas & Water Div., Memphis, Tenn.
Simpson, M. C., Jr., Virginia Polytechnic Inst., Blacksburg, Va.
Smith, G. L., Commonwealth & Southern Corp., Birmingham, Ala.
Tuholsky, A. M., Carbide & Carbon Chemicals Corp., Oak Ridge, Tenn.
Windham, J. W., Alabama Pr. Company, Birmingham, Ala.

5. Great Lakes

Alter, C. P., Indiana Bell Tel. Co., Indianapolis, Ind.
Cibelius, C. A., Jr., Barber-Colman Co., Rockford, Ill.
Cooke, S. C., Jr., General Elec. Co., Ft. Wayne, Ind.
Crothers, M. H., Univ. of Illinois, Urbana, Ill.
Curtis, C. L., American Brakeblok, Detroit, Mich.
Drack, P., (re-election), Commonwealth Edison Co., Chicago, Ill.
Elo, A. E., Perfex Corp., Milwaukee, Wis.
Fillmore, R. L., Elec. Mach. Mfg. Co., Minneapolis, Minn.
Harris, P., Hot Point, Inc., Chicago, Ill.
Hastings, L., Sibley Machine & Foundry Corp., South Bend, Ind.
Hoffman, J. R., Eli Lilly and Co., Indianapolis, Ind.
Hogan, J. C., Univ. of North Dakota, Grand Forks, N. Dak.
Howell, C. C., Trav-ler Radio Corp., Orleans, Ind.
Jaszkowski, H. N., Commonwealth Edison Co., Chicago, Ill.
Johnson, Arthur E., A. O. Smith Corp., Milwaukee, Wis.
Kahl, F. L., General Elec. Co., Ft. Wayne, Ind.
Keppert, G. D., Wisconsin Tel. Co., Milwaukee, Wis.
Kirkpatrick, C. D., Beadle Elec. Ass'n. Inc., Huron, South Dakota.
Latter, R. F., American Tel. & Tel. Co., Chicago, Ill.
Meyer, F. J., General Elec. Co., Ft. Wayne, Ind.
Patterson, P. E., Univ. of Wisconsin, Madison, Wis.
Pomatto, C. V., Westclox Div. of General Time Instruments Corp., Dalzell, Ill.
Roberts, D. M., Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.
Rosenfeldt, W. P., Harnischfeger Corp., Milwaukee, Wis.
Schloot, H. P., Square D Co., Milwaukee, Wis.
Sheekman, H. Z., Commonwealth Edison Co., Chicago, Ill.
Swanson, A. D., General Elec. Co., Ft. Wayne, Ind.
White, R. E., Iowa State College, Ames, Iowa.
Wisner, H. L., Purdue Univ., Indianapolis, Ind.

6. North Central

Maler, G. J., Univ. of Colorado, Boulder, Colo.
Rieber, R., City of Lincoln Lt. Dept., Lincoln, Nebr.
Schlosser, R. K., Bureau of Reclamation, Gering, Nebr.
Wright, G. E., 1575 Harrison St., Denver, Colo.

7. South West

Bayles, R. R., Black & Veatch, Kansas City, Mo.
Bicknell, J. E., Jr., Texas A. & M. College, College Station, Tex.
Bolling, N. F., Jr., Univ. of Arkansas, Fayetteville, Ark.
Caruthers, J. E., Arkansas Pr. & Lt. Co., Pine Bluff, Ark.
Church, T. S., Box 63, Ranchos de Taos, N. M.
Crouch, J. M., Humble Oil & Refining Co., Houston, Tex.
Cuaron, R., Cia. Mex. Prod. de Luz y Fucrza, Ciudad Juarez, Chihuahua, Mexico.
Cunningham, C. E., Humble Oil & Refining Co., Baytown, Tex.
Frumhoff, E. L., Southwest Engineers, Dallas, Tex.
Fuhrmann, C. R., Cities Service Oil Co., Bartlesville, Okla.
Glanville, C. R., Southern Methodist Univ., Dallas, Tex.
Hammond, N. C., Lieut., AA & GM Branch, The Artillery School, Fort Bliss, Tex.
Harris, J. F., Emerson Elec. Mfg. Co., St. Louis, Mo.
Howe, C. E., Emerson Elec. Mfg. Co., St. Louis, Mo.
Kerr, F. F., Empire District Elec., Joplin, Mo.
Kuhlmann, S., H., Cia Distribuidora (Westinghouse S.A.), Mexico City, Mexico.
Lambour, B., Brother, C.S.C., St. Edward's Univ., Austin, Tex.
Lovelace, J. C., Allis-Chalmers Mfg. Co., Amarillo, Tex.
Lyles, H. C., Humble Oil & Refining Co., Baytown, Tex.
Martin, T. J., Westinghouse Elec. Corp., St. Louis, Mo.
Mell, J. L., Municipal Building, Austin, Tex.
Pullen, T. F., Humble Oil & Refining Co., Baytown, Tex.
Sandford, F. F., Capitol Elec. Co., Oklahoma City, Okla.
Sissom, A. W., Texas A. & M. College, College Station, Tex.
Skitek, G. G., Missouri School of Mines, Rolla, Mo.
Thain, W. N., Grand River Dam Authority, Vinita, Okla.
Tippett, R. G., Jr., The Artillery School, Ft. Bliss, Tex.
Weldland, K. E., Oklahoma Gas & Elec. Co., Oklahoma City, Okla.

8. Pacific

Bammel, A. F., Public Service Department, Burbank, Calif.
Biesemeier, K. W., Modesto Irrigation District, Modesto, Calif.
Bonino, L., Bureau of Electricity, Alameda, Calif.
Callow, C. W., Sacramento Municipal Utility District, Sacramento, Calif.
Curtis, M. R., Univ. of Southern Calif., Los Angeles, Calif.
Dalton, C. R., North American Aviation, Los Angeles, Calif.
Daush, A. A., Jr., Univ. of Southern Calif., Los Angeles, Calif.
Erdich, I. L., C. F. Braun Co., Alhambra, Calif.
Farly, G. M., Univ. of California Radiation Lab., Berkeley, Calif.
Ferguson, J. P., Hotel Hayward, Los Angeles, Calif.
Graben, E. R., War Assets Administration, San Francisco, Calif.
Grimm, W. E., San Diego Gas & Elec. Co., San Diego, Calif.
Hill, L. H., Arizona Edison Co., Inc., Casa Grande, Ariz.
Kekauoha, G. W., Oahu Signal Service, APO 958, c/o PM., San Francisco, Calif.
Lufkin, C. R., General Elec. Co., Los Angeles, Calif.
Mayer, R. L., Pacific Gas & Elec. Co., San Francisco, Calif.
Mayers, R. W., Pacific Gas & Elec. Co., San Francisco, Calif.
Mleczko, E. L., Univ. of Southern Calif., Los Angeles, Calif.
Nixon, S. R., 3950 W. 8th St., Los Angeles, Calif.
Parrish, F. W., Stone & Webster Engg. Corp., Vernon, Calif.
Pennypacker, H. N., Jr., Bechtel Corp., Los Angeles, Calif.
Ringold, D. R., Douglas Aircraft Co., Santa Monica, Calif.
Rogers, E. H., Arizona Edison Co., Inc., Miami, Ariz.
Seltzer, L. J., 1025 South New Hampshire Ave., Los Angeles, Calif.
Sill, K. B., Southern California Tel. Co., Los Angeles, Calif.
Soderberg, C. A., Civil Service USN, San Diego, Calif.
Stuelpnagel, T. R., Hughes Aircraft Co., Culver City, Calif.
Wolfe, W. H., Bethlehem Steel Co., Terminal Island, Calif.

9. North West

Badurina, L. J., Bonneville Pr. Admn., Portland, Oreg.
Black, D. E., Pacific Pr. & Lt. Co., Sunnyside, Wash.
Colhouer, W. L., Bonneville Pr. Admn., Portland, Oreg.
Conner, G. C., Bonneville Pr. Admn., Portland, Oreg.
Coon, H. B., General Elec. Co., Portland, Oreg.
Greger, L. R., Crown Zellerbach Corp., Camas, Wash.
Holt, R. H., U. S. Bureau of Reclamation, Ephrata, Wash.
Schloth, D. G., Bonneville Pr. Admn., Portland, Oreg.
Small, R. C., U. S. Bureau of Reclamation, Coulee Dam, Wash.
Smith, J. D., Columbia Steel Corp., Ironton, Utah.

10. Canada

Bowyer, J. E., Hydro-Elec. Pr. Comm. of Ontario, Toronto, Ontario, Canada.
Harris, J. R., Canadian General Elec. Co., Peterborough, Ontario, Canada.
Helliwell, R. J., Langley Mfg. Co., Ltd., Vancouver, British Columbia, Canada.
Hoyle, W. G., Natl. Research Council, Ottawa, Ontario, Canada.
Kidd, K. H., Hydro-Elec. Pr. Comm. of Ontario, Toronto, Ontario, Canada.
Leworthy, J. V., Bell Tel. Co. of Canada, Toronto, Ontario, Canada.
Major, E. E., Hydro-Elec. Power Comm. of Ontario, Toronto, Ontario, Canada.
Shier, B. B., Automatic Elec. (Canada) Ltd., Toronto, Ontario, Canada.
Skuggevik, A. B., Hydro Elec. Pr. Comm. of Ontario, Toronto, Ontario, Canada.
Volff, C. L., The Canadian Liquid Air, Montreal, Quebec, Canada.

Elsewhere

Adkins, B., British Thomson-Houston Co., Ltd., Rugby, England.
Aultman, D. E., III, (re-election) Army Officer, U. S. Embassy, Lima, Peru.
Beauchamp, M. I., Univ. of Puerto Rico, Mayaguez, Puerto Rico.
Curtoys, C. H., A. Reyrolle & Co., Ltd., Durham, England.
John, G. C., Ordnance Factory, Ambernath, Bombay, India.
Joshi, M. V., Marconi College of Wireless, Chelmsford, Essex, England.
Kapoor, M. M., c/o Calcutta Elec. Supply Corp. Ltd., London, England.
Karaali, F., Lt., Turkish Navy Dept., Ankara, Turkey.
Krishnaswamy, H. O., The Tata Hydro-Elec. Co., Parel, Bombay, India.
Lall, M. M., Volkart Brothers, Lahore, India.
Misra, R. P., Hamara Radio & General Industries, Ltd., Delhi, India.
Oms, A. D., Enna 658 (Altos), Luyano, Habana, Cuba.
Reis, A., A. C. Cossor Ltd., London, England.
Sim, A. C., British Thomson-Houston Co., Ltd., Rugby, England.
Solaun, B. G., Compania Petrolera Shell Mex de Cuba, Habana, Cuba.
Trivedi, P. R., Electrical Dept., Alivajpur State, Central India.
Ugalde, H. H., Compania Nacional de Fuerza y Luz, S. A., San Jose, Costa Rica.

Total to grade of Associate
United States, Canada, and Mexico, 254
Elsewhere, 17

OF CURRENT INTEREST

Dwindling Resources Cost of War in Materials

One of the war's great costs to the United States is turning out to be in the basic materials that support the nation's strength according to a series of official reports bringing to light the real extent of cost in resources. Julius A. Krug, Secretary of Interior, is suggesting a $1,000,000 survey to determine exactly how much mineral wealth is left. The United States Forestry Service is recommending tighter rules on the use of timber resources.

Metal resources are depleted to a great extent because the best grade ores are gone and over five billion tons of United States minerals went into the war. Oil wells in the United States were tapped for about eight billion barrels of oil in the war period, and in the closing months of the war could not keep step with demand. Timber stocks in some of the essential categories are almost gone after three centuries of plenty. Soil resources suffered from being overcropped and certain areas are approaching the status of wasteland.

However, substitute resources were improved by the pressure of war demand. A synthetic rubber industry was built to turn out one million tons of rubber a year. And by using sea water magnesium output was increased 75 times to a 375 million pounds per year output.

Iron ore is the most important of the mineral resources and the United States has an abundant supply for future needs, but the supply of high grade ores may last less than 17 years. Today the United States gets about half of its copper from abroad, mainly because its own deposits are progressively harder to mine. Lead and zinc deposits are reported to have only a few years to last at present rates of expenditure and the result already has been felt in a scarcity of storage batteries, paint, and good gasoline for automobiles.

Higher costs for raw materials are ahead. More goods are needed to provide for a larger population. More supplies must come from farther away because United States resources can be expanded now only by digging deeper, utilizing low-grade ores, and expanding synthetics. All these methods are being used and all are more expensive.

FCC Recommends Channel Width Revision. In the belief that a width of 40 kc is necessary to separate channels in the 30–40-megacycle band, the Federal Communications Commission proposed hearings in connection with the frequency service allocations in that band. This has been required by complaints from safety and special services, including highway, maritime, forestry, and other special services that the 20-kc channel width causes interference.

Engineers Present Views on Wagner Act Changes

E. Lawrence Chandler, eastern representative for the American Society of Civil Engineers, recently gave the Senate's Labor and Public Welfare Committee the joint views (*EE, March '47, p 316*) of engineering groups that include the ASCE, American Institute of Chemical Engineers, American Society of Mechanical Engineers, American Society for Engineering Education, National Society of Professional Engineers, and AIEE, representing approximately 100,000 members. Certain sections of Senate bill 360 (the Ball bill) that would assure professional and so-called "junior" professional employees their own separate bargaining units; keep them independent of nonprofessionals; and permit them to refuse union membership without jeopardizing their right to work were endorsed specifically.

Stressing the intellectual and varied character of professional services, Mr. Chandler said the difficulty with the Wagner Act is that no distinction is made between professional and nonprofessional employees, "in spite of the fact that their viewpoints and abilities are inherently different and their conditions of employment cannot be made subject to a common standard." Representatives of the afore-mentioned six major engineering organizations and of the American Institute of Architects were among the speakers at the meeting. C. W. Ransom (A'36) of General Electric Company, Pittsfield, Mass., is the representative for the AIEE.

Paul M. Herzog, National Labor Relations Board chairman, criticized the proposed revision because it would force professional workers into separate bargaining units. He said it had been the board's practice to poll the group as to their preference, and very rarely has it directed merging real professionals with other employees.

Frequency Modulation Faces Reception Difficulties

Flaws in the reception of frequency modulation broadcasts are causing the Federal Communications Commission much concern, as well as manufacturers who are starting to produce large quantities of receivers. The difficulties have been encountered particularly where stations have been separated by only one broadcast channel. In such cases receivers have drifted with interference resulting between stations.

The FCC conducted tests recently in Syracuse, N. Y., using transmissions from *WSYR-FM* and *WFBL-FM* which are separated by only one channel. The former station had been on the air with good results prior to the time that the latter started transmitting, and then listeners began reporting interference.

Major E. H. Armstrong, who is largely responsible for the development of frequency modulation, has pointed out that the quality of the receiver is an essential factor in drift consideration. He also mentioned that even if the channel separation of stations were increased, thereby reducing the possible number of frequency modulation stations in the United States from 5,000, it would be a better thing to have 2,500 staticless frequency modulation stations than the limited 1,000 amplitude modulation stations with static.

Electrical Personnel Needed by Navy Department

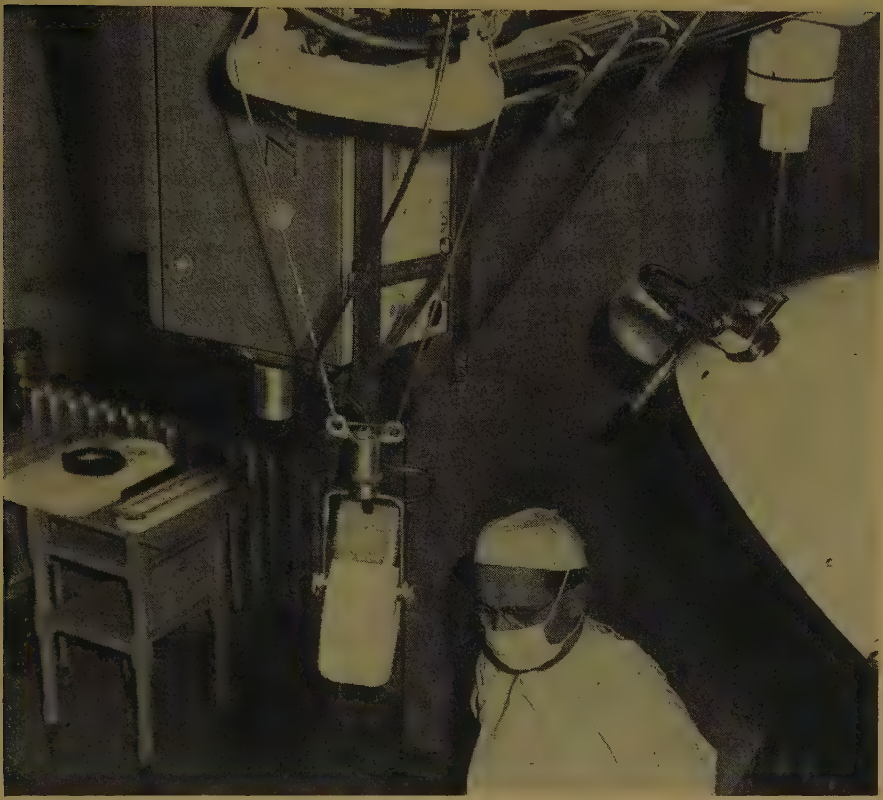
The scientific personnel branch of the United States Navy Department needs civilian personnel to fill vacancies requiring electrical engineers, electronic engineers, engineering draftsmen (electrical and electronics), radio engineers, and many other classifications. Vacancies exist at many geographical locations including Guam, Florida, Washington, D. C., and the Aleutians, and projects are as varied as air missile test, departmental service, mine countermeasures, and construction.

Information concerning the different vacancies is contained in the "Scientific Personnel Bulletin" published bimonthly by the scientific personnel branch of the Office of Naval Research. The bulletin is available at Naval activities, schools specializing in engineering and sciences, professional societies, and regional offices of the Civil Service Commission.

Electrical Statistics for 1946. The outstanding statistics for the electrical industry in 1946 show an output of 223,334,000,000 kilowatt-hours, practically the same as for 1945. Capacity was raised only 85,000 kw to bring the United States total to 50,196,000 kw. Discontinuance of energy supply to aluminum plants brings the Rural Electrification Administration power sales more nearly into line as representing rural service with a total of 2,424,000,000 kilowatt-hours. The average fuel economy for the industry established a new low record of 1.29 pounds of coal per kilowatt-hour.

Voice Library for Historical Society. The Chicago (Ill.) Historical Society inaugurated a new program recently of recording voices of leading Chicagoans on magnetic paper tape. Among the voices recorded at the meeting celebrating the 110th anniversary of the society was that of Illinois Governor Dwight H. Green. The voice library is believed to be the first of its kind in the United States.

Johns Hopkins Operation Televised



The first test of the practicability of televising an actual operation as a means of surgical teaching was presented recently by Johns Hopkins University Hospital, Baltimore, Md., in co-operation with the Victor Division of the Radio Corporation of America, Camden, N. J. One camera was mounted on the operating room light fixture directly above the operating field, which permitted a detailed view of the operation, and a second camera, equipped with a telephoto lens, was set up in the gallery of the operating amphitheater. The suspended microphone permitted the surgeon to address comments to the audience. Ten receivers on the operating floor of the hospital permitted the operation to be seen by 300 doctors

Radio-Relay Between New York and Chicago. The American Telephone and Telegraph Company, New York, N. Y., has filed an application with the Federal Communications Commission to install terminal stations in New York and Chicago, Ill., for an experimental radio-relay communication system between the two cities. The system would permit further experimentation with the radio-relay method of transmitting telephone conversations and television programs.

Engineering Who's Who Being Compiled. The sixth edition of "Who's Who in Engineering," biographical dictionary of the engineering profession, now is being compiled after consultation with the advisory committee of the Engineers Joint Council. For inclusion in the book engineers must qualify in one of the following groups: engineers of outstanding and acknowledged professional eminence; engineers of at least ten years' active experience, of which at least five years have been in responsible charge of important engineering work; and teachers who have taught engineering subjects in accredited schools for at least ten years, of which at least five years have been in responsible charge of a major engineering course. Military assignments will have proper consideration under the last two items.

New Elements Get Names. The elements with the atomic numbers 43, 85, and 87 have received new names from their discoverers. Chemical books and tables will in many cases show elements 43, 61, 85, and 87 as previously discovered and named as masurium, illinium, alabamine, and virginium. Recent researches have culminated in the new names technetium for 43, astatine for 85, and francium for 87. Only 61 remains without a name. Four elements actually discovered since the ones now named have become familiar because of the atomic bomb. They are plutonium for 94, neptunium for 93, americium for 95, and curium for 96. The last remaining unnamed chemical elements among the 96 now discovered were "christened" in April before the American Chemical Society at Atlantic City, N. J.

Power Rehabilitation for Manila. Before the war the Manila area was supplied by the Manila Electric Railway and Light Company, all of whose power supply sources were destroyed in the battle of the Philippines. The Clairaya dam of the National Power Corporation is regarded as being able to relieve, sometime this year, the 30,000-kw Army emergency floating power plant, *Impedance*, which has been in operation supplying Manila with power since the latter part of 1945. The National Power Corporation of the Philippines has compiled data and prepared preliminary reports on a total of 24 hydroelectric plants with an estimated aggregate output capacity of 850,000 kw covering more than half of the Philippine Islands' total hydroelectric potential of 1,500,000 kw.

Bulletin Published on Professional Service. A recent bulletin of the Russell Sage Foundation cites current efforts of engineering societies to improve the economic and professional status of the engineers. The 39-page bulletin entitled "The Use of Research by Professional Associations in Determining Program and Policy" also summarizes the program for improving engineering education of such organizations as the Engineers' Council for Professional Development and the American Society for Engineering Education. The publication may be obtained from the Russell Sage Foundation, 120 East 22d Street, New York, N. Y. The price is 25 cents.

High-Voltage Line Operates in France. First current flow was inaugurated through a 251-mile transmission line believed by the French to be the longest, single high-voltage system in the world, at the end of 1946 by Electricite de France, the French national electricity company. Extending from the hydroelectric center at Breuil in central France to the outskirts of Paris the line now operates as a 140,000-kw double 3-phase 220-kv system, and within two or three years the company hopes to convert the same towers to a single 3-phase 440-kv system. Work on the projected 400-kv system is in the experimental stage and a short section of line has been built at Chevilly.

Electronic Computers for Bureau of Standards. The National Bureau of Standards, Washington, D. C., has been commissioned by the Bureau of Census and the Office of Naval Research to construct two high-speed electronic, automatically-sequenced digital computing machines. The mathematical phases of the program are under the direction of Doctor J. H. Curtiss, who is in charge of the Bureau's mathematical and statistical work, while the electronic phases are being conducted by the electronics section of the ordnance development division headed by Harry Diamond. The census machine will effect economy in the tabulation of data as well as reducing their processing time. The Navy machine will be available to the armed services, other government agencies, and also to private industry.

EDUCATION • • •

New Electronics Major at Brooklyn Polytechnic. Two new courses covering television systems, all modes of modulation, ordinary broadcasting, and public address systems are available at the Brooklyn (N. Y.) Polytechnic Institute. Polytechnic was one of the centers for microwave research during the war, and Doctor Ernst Weber (F '34), who is director of the Microwave Research Institute, is head of the Polytechnic Institute's department of electrical engineering.

New Facilities. The engineering college of Duke University, Durham, N. C., plans to begin the academic year 1947–48 in a new and larger building located $1^1/_2$ miles from its present site. A 3-story building now under construction will allow the expansion of laboratory and classroom facilities to accommodate a larger enrollment and to enable the fuller development of the potentialities of each student. W. H. Hall is dean of the college of engineering; W. J. Seeley (F '45) is head of the electrical engineering department; and K. B. MacKichan (A '41) is counselor of the AIEE Student Branch.

Shrine for Virginia Polytechnic Veterans. In honor of over 7,200 alumni veterans of Virginia Polytechnic Institute a campaign was initiated recently to raise approximately $300,000 for a memorial. The shrine will include a small student chapel and the names of 310 alumni who died in service will be carved on the structure.

Quality Control at Purdue. An advanced 8-day course in quality control by statistical methods is to be presented June 27 to July 5 at Purdue University, Lafayette, Ind. It is intended for those who already have some acquaintance with statistical quality control. The course will be under the leadership of I. W. Burr of Purdue University, from whom further information may be obtained.

OTHER SOCIETIES •

ASTM Committees Meet in New York and Philadelphia

Reorganization of committee *B-1* on wires and electrical conductors was accomplished at a recent meeting of the American Society for Testing Materials in New York, N. Y. Seven subcommittees were established in addition to the advisory committee to replace the former task groups. New subcommittee VII will proceed immediately to develop specifications for aluminum conductors and aluminum cable steel-reinforced (ACSR).

At the recent ASTM committee week in Philadelphia, Pa., 22 subcommittees of committee *D-9* held meetings. The subcommittee on mica products has had in preparation standards for visual grading of mica; the subcommittee on insulating fabrics submitted a revision on cotton and rayon sleeving (*D 372*) and action was taken to revise methods of testing varnished glass insulation (*D 902*); the subcommittee on liquid insulation reported plans for a symposium and exhibit at the annual meeting; the subcommittee on plates, tubes, rods, and molded materials presented new tentative specifications for nonrigid polyvinyl tubing; and the subcommittee on conditioning submitted revised tentative methods for conditioning plastics and electrical insulating materials (*D 618*).

A report of substantial progress in evaluating cathode nickel featured the meeting of committee *B-4* on electrical heating, resistance, and related alloys at the Philadelphia meeting. Important studies on thermostat metals, contact materials, and alloys for high temperature use were also reported.

Conference on Resources Held With 75th Anniversary of AIME

More than 3,000 members and guests of the American Institute of Mining and Metallurgical Engineers attended the World Conference on Mineral Resources held March 17–19 in New York, N. Y., in conjunction with the 75th anniversary celebration of the institute which continued the remainder of the week.

On the Sunday prior to the meeting the mineral industry education division of the AIME held sessions at Columbia University. L. S. Cates, president of the institute, opened the conference Monday with an address of welcome, and introduced delegates and guests from foreign countries.

Featured during the conference on resources were sessions covering: world mineral resources, world mineral economics, the mineral industry and atomic energy, and a forecast of mineral technology at which Zay Jeffries (F '42), vice president in charge of the General Electric Company chemical department, Pittsfield, Mass., spoke on "Metals and Alloys of the Future."

Future Meetings of Other Societies

American Public Power Association. Fourth annual convention, May 21–23, 1947, Cleveland, Ohio.

American Society of Civil Engineers. Fall meeting, October 15–18, 1947, New Orleans, La.

American Society for Engineering Education. 55th annual meeting, June 18–21, 1947, Minneapolis, Minn.

American Society for Testing Materials. 50th annual meeting, June 16–20, 1947, Atlantic City, N. J.

American Society of Mechanical Engineers. Semiannual meeting, June 16–20, 1947, Chicago, Ill.; fall meeting, September 1–4, 1947, Salt Lake City, Utah; annual meeting, December 1–5, Atlantic City, N. J.

American Welding Society. Annual meeting, October 20–24, 1947, Chicago, Ill.

Association des Ingénieurs. Centenary congress and exhibition, August 30–September 13, 1947, Liége, France.

Canadian Electrical Association. 57th annual convention, June 18–20, 1947, St. Andrews, New Brunswick, Canada.

Edison Electric Institute. Annual meeting, June 2–5, 1947, Atlantic City, N. J.

Electrical Manufacturers Representatives Club of New England. Trade show, June 4–6, 1947, Boston, Mass.

Illuminating Engineering Society. East central regional conference, May 8–9, 1947, Washington, D. C.; Midwestern regional conference, May 15–16, 1947, Kansas City, Mo.; annual convention, September 15–19, 1947, New Orleans, La.

Institute of the Aeronautical Sciences. Light aircraft meeting, May 26–27, 1947, Detroit, Mich.; annual meeting, August 7–8, 1947, Los Angeles, Calif.

Instrument Society of America. Second national conference, September 8–12, 1947, Chicago, Ill.

International Lighting Exposition and Conference. November 3–7, 1947, Chicago, Ill. Sponsored by National Electric Manufacturers Association.

National District Heating Association. 38th annual meeting, June 24–27, 1947, Atlantic City, N. J.

National Electrical Contractors' Association. 46th annual meeting, September 8–10, 1947, San Francisco, Calif.

National Electric Manufacturers Association. October 27–31, 1947, Atlantic City, N. J.

National Electrical Wholesalers Association. Annual meeting, May 5–9, 1947, Atlantic City, N. J.

National Electronics Conference. November 3–5, 1947, Chicago, Ill.

National Fire Protection Association. 51st annual meeting, May 26–29, 1947, Chicago, Ill.

National Plastics Exposition. May 5–11, 1947, Chicago, Ill.

National Safety Congress and Exposition. 35th annual meeting, October 6–10, 1947, Chicago, Ill.

New England Radio Engineers. May 17, 1947, Cambridge, Mass.

Pacific Chemical Exposition and Pacific Industrial Conferences. October 21–28, 1947, San Francisco, Calif.

Refrigeration Equipment Manufacturers Association. All-Industry Refrigerating and Air-Conditioning Exposition. January 26–29, 1948, Cleveland, Ohio.

Society of Automotive Engineers. Summer meeting, June 1–6, 1947, French Lick Springs, Ind.

Society of Naval Architects and Marine Engineers. Spring meeting, May 23–24, 1947, Washington, D. C.

The remainder of the week following the conference on mineral resources was devoted to technical sessions of the AIME, one of which was on the air-borne magnetometer which was also featured at the winter meeting of the AIEE.

The president's reception and dance was held on Monday evening at the Waldorf-Astoria Hotel, and on Tuesday afternoon the president and board of directors of the American Museum of Natural History, New York, N. Y., held a reception for the members of the AIME and their guests in the mineral collection room of the museum. Wednesday evening the 75th anniversary banquet was held at the Waldorf-Astoria Hotel, and various awards were conferred on members. A feature of the evening was an address by Herbert Hoover (HM '29), who is a past president of the AIME.

Edison Foundation Seeks $2,590,000

Announcement has been made by the recently incorporated (*EE, Aug-Sept '46, p 429*) Thomas Alva Edison Foundation that Harvey S. Firestone, Jr., president of the Firestone Tire and Rubber Company, Akron, Ohio, has accepted the national chairmanship of an effort by the organization to raise $2,590,000 for financing its objectives for the next ten years. The objectives are: preservation of Edison's laboratories and library at West Orange, N. J.; establishment there of the Edison Center for Invention, Discovery, and Research, one of the important activities of which will be to study and make available to all scientists the methods developed by Edison in making his own efforts so productive; and the restoration of the nationwide Edison scholastic competition.

Henry Ford has accepted the invitation of the foundation to serve as honorary chairman of a group of industrialists, scientists, and educators who will take part in the effort to raise funds. Phillip D. Reed, chairman of the board of General Electric Company, Schenectady, N. Y., W. S. Newell, president of the Bath Iron Works, Bath, Me., and J. F. Lincoln, president of the Lincoln Electric Company, Cleveland, Ohio, will be in charge of several divisions of the fund.

NEMA Formulates Policy on Testing and Labeling

The board of governors of the National Electric Manufacturers Association recently released a tentative statement of policy regarding standards for products of the industry, testing and certification of the product as meeting the standards by independent laboratories or inspection agencies, the desirability of a co-ordinated national system of certification available to any industry desiring to use it, and methods of protecting the consuming public in the operation of such a co-ordinated certification system.

A new standard, "Proposed American Standard Practice in Public Approval and Certification Procedure (*Z34*)", is now before the ASA Standards Council for approval as American Standard. The NEMA policy statement would have the fundamental safeguards of the consuming public, which are contained in this new standard, included in the proposed co-ordinated national system of certification, according to the ASA.

Papers Invited for 1947 Electronics Conference

National Electronics Conference, Inc., is inviting papers to be submitted for possible presentation at the 1947 National Electronics Conference to be held November 3–5 in Chicago, Ill. A wide range of subjects covering essentially research, development, and application in electronics and closely allied fields will be included at the conference.

Those interested in submitting material should send a 100–200-word abstract to Doctor G. H. Fett, University of Illinois, Urbana, to reach him by June 1, 1947. All inquiries concerning papers should be sent to Doctor Fett. Accepted papers must not be published elsewhere before the conference. (See page 495).

ISO Constitution Ratified. The International Organization for Standardization, set up provisionally at a meeting of 25 nations in London, England, last October (*EE, Jan '47, p 106*), has become the official body for international standardization work following ratification of its constitution and bylaws by the national standards bodies of 15 nations according to the secretary of the provisional office. A committee is surveying the field to secure a secretary general to take charge of the new permanent ISO office which is expected to be in operation by early fall.

Tube Statistical Service Announced. The National Electric Manufacturers Association and the Radio Manufacturers Association have announced the initiation of a quarterly survey which will cover sales by manufacturers of all electron tubes except receiving, X-ray, and battery-charging types. Questionnaires will be sent to all known tube manufacturers, including those who do not belong to either trade association.

Pacific Industrial Conferences. Doctor Robert Matteson, of the American Chemical Society, has announced that the Pacific Industrial Conferences will be held concurrently with the Pacific Chemical Exposition October 21–25, 1947, in the San Francisco, Calif., Civic Auditorium. The conferences, supplementing the exhibits of the Pacific Chemical Exposition, are planned to help executives and technical personnel in all types of industrial plants.

International Electrical Standards. The International Committee on Weights and Measures recently met in France for its first official session since 1937. Technical problems considered by the committee included the practicability of adopting the wave length of some spectral lines as the primary standard of length, definition of units of heat, and revision of the international scale of temperature. Definite decisions were made to proceed with the adjustments of the units of electricity and of light which had been planned for 1940, and to introduce the new units into practice as of January 1, 1948. The electrical units designated as international are to be replaced by absolute units derived directly from basic mechanical units. E. C. Crittenden (F '44), associate director of the National Bureau of Standards, Washington, D. C., was the United States representative at the meeting.

RESEARCH • • • • •

Weather Research by General Electric and Army

Designed primarily to disperse fog and clouds over airports, a joint weather research program has been announced by Brigadier General J. V. Matejka, United States Army Signal Corps, commanding general, Fort Monmouth, N. J., and Doctor C. G. Suits (M '41), vice president and director of the General Electric Company research laboratory at Schenectady, N. Y. The Fort Monmouth Air Weather Service will make a study of cloud modifications as they apply to the military, the Army Air Forces weather detachment at Newark Airport, N. J., will fly a number of *B-29* airplanes to test techniques, and the General Electric Company will advise and instruct.

Engineers of the General Electric research laboratory recently pioneered in changing fog and clouds into snow by releasing pellets of carbon dioxide in suitable formations (*EE, Jan '47, p 105; March '47, pp 311–12*).

Problems Faced in Research Development

Research in the United States is supported chiefly by industry, universities, private foundations, and the Government. Currently the Government is supplying about half the funds spent for research. In a statement before the House of Representatives Commerce Committee, Frank B. Jewett (HM '45), president of the National Academy of Sciences, said recently that private support of research, encouraged by tax revision, is preferable to Government subsidy.

To co-ordinate efforts of those engaged in research, it has been proposed to establish a National Science Foundation (*EE, Apr '46, pp 185–6; May '46, pp 235–6*).

The proposal came before Congress in 1946, when there was disagreement as to the form and direction it should take. According to Doctor Jewett, enactment of legislation affecting research by Congress before it set up such a foundation would dislocate the traditional excellent methods of supporting research.

The success of both basic and applied research depends primarily on personnel, and the wartime manpower shortage seriously affected research staffs. William H. Higinbotham of the Federation of American Scientists, told the committee that "the danger in science today is that we may exhaust our resources of basic scientific knowledge and of adequately trained scientific personnel."

Research Activity Continues at Oak Ridge

By the close of 1948 an electric generating plant fueled solely with atomic energy is expected to be in operation at Oak Ridge, Tenn. The plant is under construction as a co-operative venture of industry under the leadership of Doctor Charles Thomas of the Monsanto Chemical Company, St. Louis, Mo., and Doctor Harry A. Winne (F '45) of General Electric Company, Schenectady, N. Y. In Atomic Energy Plant Number *1* it is planned to employ the nuclear heat from fission of the atom in the conventional fashion by developing steam as the driving medium of a turbo-electric generator.

A 100-million-volt betatron is being built by General Electric Company for the Clinton Laboratories, operated at Oak Ridge by Monsanto Chemical Company for the Atomic Energy Commission. Shipment of the machine's final components is expected to be completed this summer.

INDUSTRY • • • • •

IBEW Answers NEMA Boycott Charges. The president of the International Brotherhood of Electrical Workers, Dan W. Tracy, stated the organization is "ready to debate the allegation made by the National Electrical Manufacturers Association that the IBEW engages in so-called secondary boycotts (*EE, March '47, p 314*), if NEMA will agree to debate the effects of secondary boycotts practiced by NEMA against union products." Tracy's remarks were prompted by the announcement of R. Stafford Edwards, president of NEMA, to the effect that industry calls upon Congress to outlaw all forms of secondary boycott.

Siemens Concern Taken Over. According to a Reuter message the British Military Government has taken over the Siemens electrical concern under the provisions of Occupation Law 52 (which deals with the blocking and control of property of interest to the United Nations). Siemens, which before World War II controlled the major part of the German electrical industry, with its main subsidiary, Siemens-Schuckert, is among the Berlin industrial concerns scheduled for municipalization.

Kite Flying Leaflet. The Edison Electric Institute has sold to electric power companies more than 500,000 copies of a leaflet entitled "So You Fly Kites," which describes the dangers of kite flying with metallic string or wire. According to the Accident Prevention Committee of the EEI, electrical companies have found that the leaflet effectively supplements publicity programs on kite flying dangers.

Half Billion for Canadian Electrical Services. Within the next five years Canadian electrical utilities plan capital expenditures of some $350,000,000 for new plant, new projects, and new lines as determined from a survey by *Electrical News and Engineering* published by Hugh C. Maclean Publications, Ltd., of Toronto, Ottawa, Canada. Telephone companies plan to spend $150,000,000 thereby bringing the total to the half billion mark.

HONORS • • • • • •

Franklin Medal to Fermi and Robinson

The Franklin Medal, highest honor of the Franklin Institute, Philadelphia, Pa., was presented recently to Doctor Enrico Fermi, physicist at the Nuclear Research Institute in Chicago, Ill., and Sir Robert Robinson, professor of chemistry at Oxford University, England, along with other Franklin Institute awards at Medal Day exercises in Philadelphia. The institute's committee on science and the arts awarded the medal in previous years to Thomas A. Edison, Guglielmo Marconi, Neils Bohr, Orville Wright, and Albert Einstein.

Doctor Fermi received the medal for outstanding work in the field of atomic energy. Sir Robinson, generally regarded as one of the world's leaders in organic chemistry, was honored for his invaluable contributions to the present knowledge of the life processes of plants and animals.

The gold medal is awarded annually to workers, regardless of color or creed, who have done the most to advance knowledge of physical science and its applications.

First Alex Dow Awards Conferred. The Alex Dow Award, established by The Detroit (Mich.) Edison Company in 1946 to perpetuate the memory of its long-time president, was made recently to five employees of the company. Five awards, each consisting of a gold watch and a United States savings bond, will be made annually. Alex Dow, who died in 1942, was made an AIEE Honorary Member in 1937.

Noble Prize to ASME Member. Martin Goland, chairman of the engineering mechanics section of the Midwest Research Institute, Kansas City, Mo., has been awarded the 1946 Alfred Noble Prize for his paper, "The Flutter of a Uniform Cantilever Wing," published in the *Journal of Applied Mechanics*. Established in 1929, the award is made annually by the American Society of Civil Engineers to a young member of one of the four founder societies of the Western Society of Engineers for a published technical paper of unusual merit.

Lawrence Sperry Award. Endowed in 1936 by the sister and brothers of the late Lawrence Sperry, pioneer aviator and inventor, the award carrying his name was presented to Peter R. Murray "for radio controlled systems for guided missiles and pilotless aircraft." Mr. Murray is with the aircraft radio laboratory, Air Matériel Command, Wright Field, Dayton, Ohio.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

The Sign of Reactive Power

The following excerpts are from letters addressed to *ELECTRICAL ENGINEERING*, AIEE Standards committee, and various interested individuals, concerning the proposed change of the sign of reactive power as presented in an AIEE subcommittee report appearing in the November 1946 issue of *ELECTRICAL ENGINEERING* on pages 512–16.

. . . At the moment, the reasons seemed to me so conclusive that there should be no question but that the standard should be changed. Since that time, I understand that the college groups and those interested from an academic standpoint have submitted considerable discussion in favor of retaining the present standard. . .

. . . I believe that, basically, the move to change the sign of the quantity was based on the fact that the old standard was impractical, unworkable and substantially ignored by operating engineers, in general. Therefore, it seems to me that since the point is perhaps arbitrary from the theoretical standpoint, that we may as well adopt a standard which suits our practice and meets more nearly the effects of the flow of reactive power. . . .

R. B. MILLER (A '36)

(Engineer, Iowa-Illinois Gas and Electric Company, Rock Island, Ill.)

It would seem pertinent to inquire why the "nebulous advantages of using an unwieldly standard" were not obvious and apparent 13 years ago at the time of its adoption. The "practical reasons discussed in the next section" turn out to be "advantages" which are perhaps as nebulous as our present standard . . . if the subcommittee recommendation is the result of a two-thirds vote, what considerations contributed to this lack of unanimity?

Admittedly, the concept of power factor is basic and indispensable, and the term lagging current quite generally implies specification of this current with respect to its driving voltage. Thus, the voltage becomes the reference quantity, and it is difficult to picture a concise and consistent development of circuit theory, which did not include this fundamental concept, or its equivalent. . . .

Nevertheless, after some 13 years, the suggestion is made that the current be substituted as the reference quantity, for no other apparent reason than to justify the proposed choice of the positive sign for inductive reactive power. . . .

Viewed pedagogically, the writer would feel himself at a distinct disadvantage, if he should ever find it necessary to justify to a group of critical students, the desirability and necessity of the proposed revision.

H. B. HANSTEEN (M '43)

(Associate professor of electrical engineering, Cornell University, Ithaca, N. Y.)

. . . During the last ten years I have worked with engineers in most of the power companies within 500 miles of Chicago, and I never have met one who thinks in terms of the reactive power of an induction motor flowing in a direction opposite to that of the real power. Since we in the power field are the ones who make most continuous use of this quantity, it would seem to be a definite mistake to have the standards set up with the opposite concept. The sign of inductive reactive power should be positive and not negative.

L. B. LEVESCONTE (M '43)

(Sargent and Lundy Engineers, Chicago, Ill.)

. . . I would like to add my support to the movement for reversing the sign of reactive power . . . in operation of the network calculator and in calculation of flow of reactive power on electric power systems, all of the companies with which I have been associated, have used that concept. From the contacts and experience I have had, it would appear that the operating and manufacturing companies definitely would prefer the change in the standards.

J. E. HOBSON (M '41)

(Director, electrical engineering department, Illinois Institute of Technology, Chicago)

. . . In line with our conception of supply of real and lagging power to consumers, for many years we have used the plus sign for lagging reactive power in work with the calculating board and in connection with operating the system. It is recommended that the AIEE Standards committee also adopt the plus sign.

HERMAN HALPERIN (F '45)

(Staff engineer, Commonwealth Edison Company, Chicago, Ill.)

It was shown . . . that whether reactive power is positive or negative depends on whether it is defined with respect to the series or parallel circuit. This is misleading as it gives the idea that reactive power in an inductive series circuit is opposite in sign to that in an inductive parallel circuit; an obviously false conclusion.

Whatever convention is adopted, it should not lead to mistaken concepts and, to be consistent, it must give the same sign for inductive reactive power, irrespective of the mode of connection. This ideal is possible if the convention relates, not to the sign of the reactive power, but to the more fundamental consideration of the sign of the angle between voltage and current vectors. . . .

Since the power absorbed by a circuit concerns the total current entering the circuit and the total voltage across it and is not concerned with component currents or voltages, it is no longer necessary to have sometimes voltage, sometimes current as the common reference quantity depending on the nature of the circuit. . . .

All that is necessary to avoid the confusions of series and parallel circuits is to make the convention sufficiently basic, by declaring voltage or current as the fundamental quantity.

F. DE LA CHARD

(Lecturer in electrical engineering, University of Bristol, England)

. . . I assume that the change will be effected unless there is some protest from members of the profession.

I believe it is almost universal among operating electrical engineers to consider magnetizing kilovolt-amperes as a positive quantity. We consider that an inductive load takes magnetizing kilovolt-amperes from the system and that overexcited generators, synchronous condensers, capacitors, and line capacitance supply magnetizing kilovolt-amperes to the system. . . .

I am not a sufficiently good mathematician to understand the effect of changing the sign of reactive power. I know that the present system works satisfactorily for voltage drop calculations. . . . I believe that engineers in general have adopted the existing standard of using opposite signs for real and imaginary power where current lags voltage and that considerable confusion will result from a change.

I thoroughly agree with Doctor Silsbee (*EE, Dec '46, pp 598–9*) that a better term should be invented for the quantity that is measured in vars. Doctor Silsbee suggests that "quadergy" be used for this term. "Quadergy" is derived from quadrature energy and I cannot see that this expresses the quantity any better than "reactive power." We have a satisfactory term (vars) in which to measure this quantity but we need a name for it.

I hope the committee will leave the sign of reactive power unchanged.

G. M. TATUM (A '40)

(Superintendent of operation, western division, Virginia Electric and Power Company, Charlottesville)

. . . The subcommittee's recommendation to change the sign of reactive power is one means of eliminating some of the existent confusion insofar as practical considerations are concerned. However, the change of sign will introduce difficulties in mathematical analysis involving reactive power.

. . . If the sign is changed, inductive reactive power then must be represented by an upward or positive vector which normally would be the projection of a leading current vector. This would be confusing as well as inconsistent with conventional vector analysis. We believe that the present choice of sign, based on the parallel circuit should be retained.

In order to obtain clarity in discussions and considerations involving reactive power, specific terminology should be applied to this quantity. There would be no confusion if engineers talked in terms of inductive reactive power, capacitive reactive power, inductive vars, capacitive vars instead of simply reactive power and vars. New terms for the two types of reactive power and their unit measure would fill a definite need and eliminate the difficulties resulting from vague terminology which is loosely used.

A. B. CRAIG (M '33)

(Head, meter section, transmission and distribution department, Boston (Mass.) Edison Company)

. . . To me, the significant fact is the convention that gradually has developed concerning the manner in which the system operator dispatches reactive kilovolt-amperes. Without mental effort or reasoning the operator instinctively refers to a generator as supplying more reactive kilovolt-amperes as the excitation is increased, as an overexcited synchronous condenser as supplying reactive, as an underexcited synchronous condenser as absorbing reactive kilovolt-amperes, as a capacitor supplying reactive kilovolt-amperes, or as a motor absorbing reactive kilovolt-amperes. In all these cases he unwittingly uses lagging reactive kilovolt-amperes as positive and thinks in terms of dispatching this quantity.

It is gratifying, therefore, to see the standard reversed so that it is consistent with the one convention that has real significance.

C. F. WAGNER (F '40)

(Manager, central station engineering department, Westinghouse Electric Corporation, East Pittsburgh, Pa.)

. . . In all of our a-c network analyzer studies, we have represented lagging reactive power as $+jQ$ for reasons 3 and 4 submitted by the committee report.

However, other electrical utilities interconnecting with us make similar studies of joint interest in which the opposite standard is used. In such cases we, however, submit our data to them with reference to our standard but they in turn submit the network analyzer results in terms of their standard.

Usually no confusion arises, since the standard that is used can be determined by inspection of the results, but the adoption of a single standard would be, of course, desirable.

H. A. DAMBLY (F '42)

(Engineer, system planning, transmission and distribution section, Philadelphia (Pa.) Electric Company.)

The choice of sign for reactive power, of course, would be arbitrary if starting anew, but it is undesirable to do this. Because certain more basic concepts concerning electrical quantities involving arbitrary choices have been accepted, these provide the basis for a decided preference for the choice of sign (+) recommended by the subcommittee.

In our view the decisive factor to be considered is the concept involving the flow of reactive power in a manner analogous to the flow of real power . . . the recommendations of the subcommittee correspond with analytical studies made by the majority of the utilities. This is a factor of considerable interest from the standpoint of engineering students.

While it is true that the majority of the opinions of the 1935 subcommittee was in favor of the recommendation, their action was at variance with the preponderance of usage in the plotting of power-circle diagrams and in the analytical expressions used for obtaining the expression for power and reactive power from a voltage and a current. Now after 15 years trial, the present subcommittee recommends the sign of reactive power which corresponds with the first extensive use of power-circle diagrams and analytical expressions for obtaining the quantity $(P+jQ)$.

The experience of these two AIEE subcommittees on the sign reactive power deserves further consideration. The first subcommittee hoped to gain acceptance of a rule which was contrary to the preponderance of usage as reflected by AIEE papers and books of a pioneering nature published prior to that time. The alternative and the one being adopted by the present subcommittee is to follow usage and lend the prestige of the Standards committee for the purpose of making the practice uniform throughout the industry.

R. D. EVANS (F '40)

(Consulting transmission engineer, Westinghouse Electric Corporation, East Pittsburgh, Pa.)

. . . Although the article stresses the calculations of real and reactive power, in actual practice we very seldom compute these quantities since they are usually known or read on an a-c board, or the sending end value may be obtained by adding the real and reactive losses to the receiving end values. However, since the voltage drops are frequently calculated, it seems more reasonable to use the sign which will cause the least confusion in the computation of voltages. . . .

It is difficult to see the need for changing a standard which was adopted by the American Standards Association as late as 1942, and also by the International Electrotechnical Commission at some recent time, especially since it is admitted that either sign has "about equal technical validity." I see only two things to be achieved by the change in sign—additional confusion in its use, and a question from other nations about our ability to make up our minds. It seems to me that since there is no strong argument either way, and we just recently have agreed on a sign, we may as well end these arguments and retain the present standard.

R. C. R. SCHULZE

(American Gas and Electric Service Corporation, New York, N. Y.)

. . . As Mr. Schulze has pointed out, changing the sign of lagging reactive kilovolt-amperes from minus to plus when this is used in complex notation will run into difficulty in connection with calculation of voltage drop where we now use the positive sign for reactance. This comes about from the use of the vector diagram which employs voltage as a basis in ordinary voltage calculations. This is the common and, I believe, most convenient procedure. From this standpoint, therefore, there appears to be no reason whatever for changing the sign of reactive kilovolt-amperes from minus to plus but rather a good reason for not changing it. . . .

In common with most systems, our system started out many years ago with the practice of marking reactive-kilovolt-ampere meters in terms of leading and lagging with a tie to the "in" or "out" flow of kilowatts. At least 15 years ago, this practice was entirely changed and reactive kilovolt-amperes meters were marked, "Reactive kilovolt-amperes in" and "Reactive kilovolt-amperes out." At the same time, it was agreed that the only kind of reactive kilovolt-amperes that would henceforth be talked about or considered in system operation would be *lagging* reactive kilovolt-amperes, and it was also agreed that reactive kilovolt-amperes so defined would be treated as a separate quantity flowing in or out from a bus entirely independent of the direction of flow of kilowatts.

This scheme has worked beautifully on our system and is well-liked by the entire operating personnel. I believe the same method is used in a great many if not the majority of all operating systems at this time. . . .

We have been using this designation for some 18 years of network analyzer studies involving four or five different boards, and it has not been the cause of any particular inconvenience or confusion in our own experience. Actually, we believe more confusion would result from any attempt to change the reactive kilovolt-amperes sign because of the accompanying change, which would have to be made in the sign of reactance in our present expression $R+jX$.

H. P. ST. CLAIR (F' 44)

(System planning engineer, American Gas and Electric Service Corporation, New York, N. Y.)

. . . In a circuit containing inductance and resistance, or one in which the current lags in time phase with reference to the voltage, the reactive power which is the imaginary component of the total power, leads the real component by 90 degrees in phase or whether it lags 90 degrees with reference to the real power. If the imaginary component leads the real component by 90 degrees it would be considered as positive reactive power and if it lags by 90 degrees it would be negative reactive power.

The total power or the volt-amperes is the product of volts times amperes and from this one might expect it to be the algebraic product; that is, a product obtained by multiplying according to the rules of complex algebra, but this would be incorrect because power is a double frequency quantity which surges in the circuit at twice the frequency of the current and voltage. The correct result is the vector product of current and voltage. This is explained by the late Doctor C. P. Steinmetz[1] where he shows that the real power is $EI \cos \phi$ and the reactive power is $EI \sin \phi$. The reactive power therefore may be considered as positive when $\alpha>\beta$ and negative when $\alpha<\beta$ if the phase displacement $\phi=\alpha-\beta$ is positive.

However, in obtaining the vector product of current and voltage he has assumed the voltage to operate on the current; if he had assumed the current to operate on the voltage the result would have been the opposite. The sign of reactive power has been discussed by La Cour and Bragstad,[2] in which the authors conclude that reactive power may be considered as either positive or negative.

In deciding the question, reactive power in the watt triangle of real, reactive, and total power might be considered the same as reactance has in the impedance triangle in which the reactance is assumed to be positive in an inductive circuit and negative in a capacitive circuit. It may be that a study of instantaneous condition will influence a decision on the subject. . . .

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2. Theory of Electric Currents (book), **J. L. La Cour, O. S. Bragstad.** Longmans Green and Company, New York, N. Y., 1913. Pages 34–8.

C. F. ESTWICK (M '25)

(Electrical department, George C. Sharp, Consulting Engineer, New York, N. Y.)

I warmly welcome the decision . . . to take the reactive power as positive for inductive reactive power . . . electric circuit theory for a-c networks is based on Ohm's Law in its appropriately extended sense; that means that we build the structure of electric circuit theory on the basis of the impedance relation between voltage and current. . . . The admittance relation between current and voltage is introduced in an advanced state of electrical thinking. . . . In making clear that the impedance relation between voltage and current is the fundamental relation in electric circuit theory, and the admittance concept merely a derivative from the impedance concept, we eliminate any arbitrariness in the decision on the sign of reactive power.

R. FEINBERG

(Electrotechnics department, University of Manchester, England)

Many excellent arguments have been advanced which tend to show that either the plus or minus sign is basically correct. It seems unfortunate, therefore, that the standard adopted should be opposite to commonly accepted usage of power engineers, who are the ones most concerned with the production, measurement, sale, and use of reactive power or kilovars . . .

However, in conformity with the present standard, the sign on the kilovars is negative. So the bill for electrical service should include a charge for kilowatts supplied to the load plus a charge for receiving kilovars from the load, a very unsatisfactory and artificial method of evaluating the service.

. . . Overexcitation of a generator causes it to deliver a lagging current. But overexciting a synchronous motor (the same type of machine) causes it to take a leading current. This apparent contradiction in behavior is caused by the old notion that a generator supplies current and that a motor consumes current.

Current flows in the windings of both motors and generators, and in either case just as much is supplied to the line on one side of the winding as is taken from it on the other.

A generator supplies power, not current. A motor draws power from the line. When either type of machine is overexcited, it produces kilovars; underexcitation causes consumption of kilovars, which must be produced somewhere else in the system. In this terminology there is an elegant simplicity of concept, which is lost in the emphasis on two kinds of kilovars, plus and minus. The idea of negative kilovars is as unnecessary and repugnant as negative watts or negative amperes.

J. S. GAULT (M '30)

(Professor in electrical engineering, University of Michigan, Ann Arbor)

Stanley and the Self-Regulating Transformer

To the Editor:

In an article by J. K. B. Hare, entitled "George Westinghouse — Individualist," which appeared in the October 1946 issue of *ELECTRICAL ENGINEERING*, the following statement is made: "The French engineer, Gaulard, and the Englishman, Gibbs, contributed the basic transformer; but Westinghouse (aided by William Stanley and Albert Schmid) redesigned the crude invention of Gaulard and Gibbs into a practical device." Statements which appear in the official organ of one of the major engineering societies generally are accepted by both professional engineers and laymen as factual. Without any intention on my part of detracting from the achievements of Westinghouse as an industrialist or as an engineer, I respectfully request the privilege of correcting this statement.

As will be developed in ensuing paragraphs, neither the self-regulating transformer nor the a-c system in which it is utilized was the result of redesign of the Gaulard and Gibbs apparatus or the methods of distribution they proposed, but was based upon fundamentally different principles which were developed independently by William Stanley. This is evidenced by the issuance of the self-regulating transformer patent to William Stanley and by the acknowledgment and tribute paid to him as its inventor by all Sections of AIEE in 1936, upon his transformer's 50th anniversary.

A detailed reivew of the course of events leading up to the development and demonstration in Great Barrington, Mass., in March 1886, of the self-regulating transformer and the a-c system, essentially as now employed, would be unduly long and unnecessary. It is sufficient to say that Stanley already had developed certain theories of his own in respect to the use of alternating current previous to the time he became associated with Mr. Westinghouse at Pittsburgh in 1884. . . . When the Westinghouse Company obtained the American rights to the Gaulard and Gibbs inventions, Stanley's studies and investigations of that system, long before the arrival of the apparatus in this country, led him to conclude that it had no practical value.

A brief reivew of the Gaulard and Gibbs apparatus and method of distribution follows. A number of (straight iron core) induction coils (inductoriums) were connected in series on the primary side to an alternator, designed to furnish constant current with varying potential (as compared with the constant voltage of the systems later universally utilized). The ratio of transformation generally was one to one . . . and there were no means of stepping the voltage up at the source of power. The maximum potential depended upon the limits in design of the alternator.

Stanley continued to advocate the further development of his own theories but failed to obtain the active support or interest of Westinghouse. Being a victim of frail health and yet determined to prove that his conclusions were correct, he moved his home to Great Barrington, Mass., where he could benefit from the climate and also devote his time exclusively to the development of his system. Under this arrangement Stanley continued to be associated with the Westinghouse Company and received certain equipment, with which to carry on his research and experiments. . . .

The method of distribution devised by William Stanley and put into operation at Great Barrington in 1886, employed an alternator operating at constant voltage as distinguished from constant current, and the transformers (or converters as they then were called) utilized a closed instead of an open magnetic circuit. The Siemens alternator, which Westinghouse had imported from England in conjunction with the Gaulard and Gibbs apparatus, was redesigned by Stanley to deliver constant voltage. . . .

Owing to inherent characteristics which made satisfactory regulation impossible, the system and methods proposed by Gaulard and Gibbs did not survive . . . (but) the system and apparatus developed by Stanley for transmission of alternating current at constant voltage were in all essential respects identical to that utilized today, and that they permitted a wide range of transformation and transmission. . . .

When Stanley set up and tested out his "plant" successfully in the spring of 1886, he promptly reported his accomplishments to Pittsburgh, but received no response from those whom he believed should be interested. This incident is described best by a letter dated November 25, 1922, from Colonel H. M. Byllesby, former vice-president and general manager of the Westinghouse Company, to T. C. Martin, former editor of *Electrical World*, from which I quote:

> In those days Stanley had taken up his residence at Great Barrington, Mass., where he was equipped with a laboratory and where he installed the first real alternating current plant in the United States.
>
> I had known Stanley for several years prior to joining Mr. Westinghouse's interests. There was a mutual liking between us and sometime in February or March, 1886 . . . Stanley came down to see me at New York on a Friday and impressed me with the fact that he actually did have a small alternating current station running at Great Barrington that he could receive no audience from any of his associates in the company and he implored me to go back to Great Barrington with him and look at it.
>
> This I did, and spent the following Saturday there. I found he had a complete system . . . actually performing and performing well and with relatively slight modifications could be put upon the market.
>
> I returned to Pittsburgh and reported to Mr. Westinghouse and my associates. I was enthusiastic.

All of them, even Mr. Westinghouse, were somewhat skeptical but we immediately had a thorough examination made which proved that the alternating current system had arrived successfully.

Throughout his life, William Stanley avoided personal publicity concerning his contribution to the development of the electrical and industrial arts. Knowledge that he had contributed to human progress was the major reward he sought. His work and accomplishments are to be the subject of a biography which is now in the course of preparation. Meanwhile, as is evident from the foregoing, the development of the basic principles of the self-regulating transformer—which have remained unchanged for 60 years—and its application to the transmission of alternating current was the achievement of William Stanley.

LEONARD L. STANLEY (A '37)

(Vice-president, Day and Zimmerman, Inc., New York, N. Y.)

Forces Between Moving Charges

To the Editor:

In connection with the paper "The Forces Between Moving Charges," by Professor Sard, *ELECTRICAL ENGINEERING*, January 1947, consider the following problem:

In Figure 1a, q is a charge moving with constant velocity v. The plane of a fixed turn of wire, C, passes through the path of q. Then as q passes, its magnetic field, linking C, changes, so an electromotive force is induced around C.

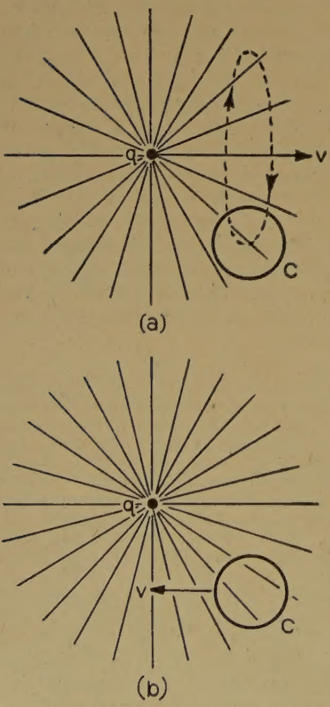

Figure 1

In Figure 1b, q is a stationary charge and the same turn C is moving with constant velocity v. Every charge in the wire experiences a force due to the electrostatic field of q, but as the line-integral of an electrostatic field around a closed path is always zero, and there is no magnetic field, there can be no electromotive force induced around the moving loop.

Since in both cases the relative velocity between q and C is the same, what is the explanation of this anomaly, in terms of the generally accepted theories of electromagnetism and relativity?

It is well known that Maxwell's theory is based on the fundamental postulate of a material medium or ether to which all velocities can be referred. Such velocities are *absolute*. Nowadays, however, it is generally accepted that only *relative* velocity has any physical meaning, but at the same time students are still taught to regard Maxwell's equations as expressions of fundamental physical truth. All goes well so long as our current circuits and magnets are stationary, however rapidly the currents may be alternating, but our credulity is stretched to fantastic limits when we apply the theory to account for the effects of moving magnets, as I have shown in the *Electrician* of October 18, 1940. So far, however, there has been little experimental evidence to show in what circumstances Maxwell's equations lead to incorrect results, so far as macroscopic phenomena are concerned.

The foregoing problem can be made the subject of an experiment. Referring to Figure 2, pairs of parallel conducting plates $a - a$ are maintained at a constant potential difference, so that the direction of the electrostatic field between the plates is opposite for adjacent pairs as shown. The dotted path b is in a plane normal to the lines of force so that if the whole system of charged plates moves with constant velocity from left to right the fixed path b will be linked by a changing electric field. Then by Maxwell's equation:

$$\nabla \times H = D \qquad (1)$$

a magnetic field should be induced around the dotted path. If the plates are properly shaped the electrostatic flux linking the path b can be made to alternate sinusoidally, so that the magnetic field around b should also alternate sinusoidally. Now place a toroidal coil to occupy the path b. The alternating magnetic flux given by equation 1 will link, if it exists, the turns and will induce an electromotive force in the coil, which may be calculated from the equation:

$$e = -N\frac{d\phi}{dt} \qquad (2)$$

Let $\mathcal{E}_m$ be the maximum value of the electrostatic field (at the center of the plates) and the area of the path b be A. Then the electrostatic flux linking b is given by

$$\Psi \approx \frac{2}{\pi} k_0 \mathcal{E}_m A \sin \omega t \qquad (3)$$

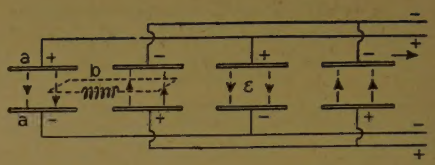

Figure 2

If L is the length of the closed path b, and B the average value of the magnetic flux density induced around the path by the changing electrostatic flux Ψ, equation 1 leads to

$$BL = \mu_0 \frac{d\Psi}{dt}$$

or

$$B = \frac{2A}{\pi L} \mu_0 k_0 \omega \mathcal{E}_m \cos \omega t \qquad (4)$$

If a is the area of each of the N turns of the toroid filling the path b, the electromotive force induced in the coil by the magnetic flux $\phi = aB$ is

$$e = -N\frac{d\phi}{dt} = \frac{2aAN}{\pi L c^2} \omega^2 \mathcal{E}_m \sin \omega t$$

which has an rms value

$$E = \frac{\sqrt{2}aAN}{\pi L c^2} (\omega^2 \mathcal{E}_m) \qquad (5)$$

If p similar toroids are situated between p pairs of plates and connected in series, putting $\omega = 2\pi f$ the total generated electromotive force in this stationary "armature" is

$$E = \frac{4\sqrt{2}\pi a p A N f^2}{L c^2} \mathcal{E}_m \qquad (6)$$

where c = velocity of light and $\mu_0 k_0 = 1/c^2$.

Putting in practical values, suppose that 20 pairs of plates are arranged around two parallel insulating disks rotating at 3,000 rpm. Then $f = 500$ cycles per second. If

$a = 2 \times 10^{-4}$ square meter,
$p = 20$
$A = 10^{-2}$ square meter,
$N = 500$ turns per coil,
$f = 500$
$L = 0.4$ meter,
$c^2 = 9 \times 10^{16}$

and

$\mathcal{E}_m = 10^6$ volts per meter

then

$$E = 2.5 \text{ microvolts, approximately} \qquad (7)$$

which is a measurable quantity at 500 cycles.

Since the passage of the coils between the charged plates will cause a fluctuation of their capacitance, there will be a fluctuation of charge on the plates and the coils which will comprise a small alternating current. This will result in a small electromotive force in the coils, whose value will be a function of the periodic change of capacitance but which is small compared with E.

The known facts of electromagnetic induction, as discovered by Faraday, give two experimental methods of inducing an electromotive force in a conductor: (a) when the conductor moves relatively to a constant-current system or magnet (motional electromotive force), and (b) when the conductor is stationary relative to a current system in which the current is changing (transformer electromotive force). For closed rigid circuits, equation 2 gives the value of the induced electromotive force for either method or for any combination of the two. It is not clear, however that either of these two necessary conditions exists in the proposed experiment. There cannot be said to be relative motion between the coils and a constant-current circuit, and, apart from the small "reaction" electromotive force, no charges are accelerating in the same way as when an alternating current flows.

And yet, by Maxwell's equations, an electromotive force should be induced. This is because, by Maxwell's hypothesis, the motion of an electrostatic system past a fixed point is supposed to cause a displacement current which is attended by a magnetic field. The proposed experiment, which is a modification of Rowland's famous experiment with a different method of detecting the magnetic field of moving charges, therefore appears to be of some fundamental interest.

E. G. CULLWICK (M '33)

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Electrical Essay

To the Editor:

A solution to the transformer problem described by Mr. Richter in the January 1947 issue, page 44, appears to be the following.

The transformer is assumed connected to two sources of alternating electromotive force, one at the left and the other at the right. When one acts as a generator, the other acts as a motor load and vice versa. When there is no load on one side, the machine on that side is adjusted to draw no current and exciting current is supplied by the other machine. Frequency is held absolutely constant and no slip is permitted.

The man in the compartment will be provided with a high resistance voltmeter of proper range, a loop of wire around the transformer core, and a local source of alternating electromotive force of the same frequency as the alternators. This local source of electromotive force should have variable voltage and a phase shifting device. Frequency can be held absolutely constant.

The principle to be used is that at no load the flux in the core of a transformer is slightly greater than at full load. Also that the flux shifts 180 degrees when exciting current is shifted from one side to the other (with due regard for polarity). The electromotive force in the loop is a measure of the flux in the core.

The procedure is to connect the voltmeter to the loop. As load changes from one side to the other, and zero load changes from one side to the other, the reading of the voltmeter will vary between two values, a high and a low. The high value indicates no load on some side which we will assume to be the right side. Under this condition, the local source of electromotive force is introduced in series with the loop and meter. Its phase and voltage is adjusted until voltmeter reads zero. We call this reading V_{0r} or no load on right. If load now appears on the right, there will be a small reading on the voltmeter called V_{lr}. If load is removed and the right side becomes primary, supplying exciting current, then the voltmeter reads a maximum called V_{0l}. If load now is put on the left, the voltmeter will read slightly less than the maximum, called V_{ll}.

We thus have four voltmeter readings, which follow in order of their relative magnitudes. (Their absolute values in volts have no significance.)

V_{0r}—No load on right, supply on left, voltmeter reads zero.

V_{lr}—Load on right, supply on left, voltmeter reads small.

V_{ll}—Load on left, supply on right, voltmeter reads large.

V_{0l}—No load on left, supply on right, voltmeter reads maximum.

After establishing the zero reading standard and making an assumption that it indicates no load on, for example, the right, our engineer in the compartment can make the following statements according to his meter readings:

There is no load on the right.
There is full load on the right.
There is no load on the left.
There is full load on the left.

Of course, right and left have no meaning to the man in the compartment. He can reverse them merely by standing on his head!

CHARLES B. SAXON (M '42)

(Consulting engineer, New York, N. Y.)

For More Practical Electrical Definitions

To the Editor:

One important advantage of the new publication policy is that more letters to the editor can be included in *ELECTRICAL ENGINEERING*. The presentation each month of a representative cross section of membership opinion would be ideal. With expanding membership adequate representation becomes more and more of a problem.

Perhaps this and other problems faced by the AIEE would be clarified somewhat if a truly representative member could be imagined. As a first approximation such a member, I think, would be alert, ambitious, resourceful, progressive, and last but not least, *predominantly practical* yet well fortified by theory. It should be possible to check the italicized attribute against such composite AIEE products as the various Standards and the "Definitions of Electrical Terms" (ASA *C42-1941*).

In general, the Standards *must* be practical because specifications based upon them often are incorporated in contracts. The following quotation from page 3 of *C42* indicates a similar objective for the definitions:

"The primary aim . . . has been to express for each term the meaning which is generally associated with it in electrical engineering. . . . When possible, the definitions have been generalized . . ., the greatest weight naturally being given to the strictly engineering applications . . . the preferred definition is a simple one . . ."

The bulk of the definitions in *C42* appear to be in accord with the quoted aim, but many in the prominent first part (Group 05) do not. For example, opposite terminal in the index is 05.21.006 which reads in part as follows:

"Point of Entry (Terminal). A point of entry for a conductor entering a delimited region is that equipotential cross section of the conductor which coincides with the bounding surface of the region." There are two more sentences and a long note in which terminal is mentioned. Compare this with the following from a dictionary:

"A device attached to the end of a wire or cable or to an apparatus for convenience in making electrical connections."

The electrical industry has been in existence long enough for the general public to become familiar with some of the terminology and this is reflected by the dictionaries. The need for specialized definitions can be met best as in the past by AIEE publications like *C42*, but the quoted aim should not be overlooked. Definitions of a theoretical nature like 05.21.006 preferably should be relegated to an appendix until the industry catches up with them.

In conclusion, it seems desirable on general principles for the definitions in the main part of *C42* to be predominantly practical and thus representative of the membership. To continue the present arrangement might affect adversely the effort to raise the status of the profession. It would be unfortunate if that portion of the public which has to refer to *C42* got the impression that the primary aim is to mystify rather than to enlighten!

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For Adoption of Metric System

To the Editor:

I was pleased to see, in the articles in your May and June 1946 issues by Nikiforoff and coauthors, on Mexico's electrification program, that quantities generally are expressed in metric units—the practice doubtless followed by the authors in their original paper. Though this policy is not followed, invariably there is free use of such units as cubic meters per second and square kilometers, with metric measures in some cases followed by English equivalents in parenthesis. Fortunately, electric units are now on the metric basis.

It appears desirable for American engineers and writers to recognize that practically the entire world, except the United States and Great Britain, utilizes the metric system. *ELECTRICAL ENGINEERING* doubtless has many readers throughout the non-English-speaking world, and it would seem wise to cater to them in some degree, rather than use English units exclusively in your articles.

Our company has used metric units for several decades in drawing engineering plans for plants in countries that have adopted the metric system. Engineers and draftsmen soon become proficient in using the metric. We therefore are interested in metric progress in this country; delay and expense result from the necessity of conversion as between systems. Personally, I hope that, over a reasonable period, the metric system may be adopted in the United States.

LOUIS ELLIOTT

(Consulting mechanical engineer, Ebasco Services, Inc., New York, N. Y.)

NEW BOOKS • • •

"Work Measurement Manual." Those interested in improving the ability of time study men to set accurate and consistent time standards will find this volume a valuable guide. The importance of time study and the procedures commonly used in making time studies are explained, as well as the work measurement investigations now being conducted by the author. A section is devoted to the use of standard motion–time data for various specific operations. Full report is given of the author's recent industrial engineering survey of 80 industrial plants. By Ralph M. Barnes. William C. Brown Company, Dubuque, Iowa, 1947, 218 pages, $8^1/_2$ by 11 inches, paper, $3.75.

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

SCIENCE REMAKES OUR WORLD. By J. Stokley. Ives Washburn, New York, N. Y. Revised edition, November 1946. 318 pages, illustrated, $8^3/_4$ by $5^3/_4$ inches, cloth, $3.50. In simple, nontechnical terms the author describes the scientific developments of recent years and shows how they affect our everyday life as well as the technical fields involved. The wide range of topics includes plastics, chemurgy, color photography, television, sulfa drugs and penicillin, jet propulsion, radar, and rockets. An insight into the future is provided in the material on helicopters, light that flows around corners, three dimensional movies, atomic power, and so forth.

2,100 NEEDED INVENTIONS. By R. F. Yates. Wilfred Funk, Inc., New York, N. Y., 1946. 252 pages, $7^1/_2$ by 5 inches, cloth, $2.50. The first few chapters briefly describe the general subject of invention and its rewards and discuss the patenting and handling of inventions. In succeeding chapters the specific suggestions are classified in some 35 subject groups covering virtually the whole field of commercial endeavor.

VARNISHED CLOTHS FOR ELECTRICAL INSULATION. By H. W. Chatfield and J. H. Wredden. J. and A. Churchill Ltd., London, England, 1946. 255 pages, illustrated, $8^1/_4$ by $5^1/_4$ inches, cloth, 21*s*. The authors have brought together in this book a considerable amount of ordinarily scattered information. Four basic topics are dealt with: the textiles which form the supporting fabric; the impregnating varnishes; the manufacture of the treated fabrics; the properties and uses of the varnished cloths as insulating mediums. Additional information is given on methods of storage, analysis, and testing of the raw materials and the finished product.

WOMEN CAN BE ENGINEERS. By A. C. Goff. Apply to author at 153 Lauderdale Avenue, Youngstown, Ohio, 1946. 227 pages, $8^3/_4$ by $5^1/_2$ inches, cloth, $2.50. In part I the author presents biographical sketches of 13 women who have achieved success in the engineering field. The emphasis is on their work and is designed to show what can be done as well as what difficulties may arise. Part II presents similar information about six other women who have done effective work in allied technical and scientific fields.

MITTEILUNGEN AUS DEM INSTITUT FÜR HYDRAULIK UND HYDRAULISCHE MASCHINEN. Eidgenössischen Technischen Hochschule in Zürich. Verlag Ag. Gebr. Leemann and Co., Zurich, Switzerland, 1946. Illustrated, $9^1/_2$ by $6^1/_2$ inches, paper. 1. Untersuchungen über den Einfluss der Schaufelzahl auf die Wirkungsweise eines Freistrahlrades. By H. Fikret Taygun. 82 pages, 7.20 Swiss francs. 2. Der Einfluss der Schaufelzahl des Laufrades auf den Wirkungsgrad bei Kreiselradmaschinen (Überdrucklaufräder). By M. I. Hassan. 69 pages, 7.50 Swiss francs. Two communications from the Swiss Institute for Hydraulics and Hydraulic Machinery describe the test methods and equipment, the necessary calculations, and the effective results of investigations on the following: (1) The influence of the number of blades on the mode of action of an impulse wheel (17, 20, and 23 blades respectively are considered). (2) The influence of the number of blades of the runner wheel on the efficiency of turbines (figures for 11, 15, and 19 blades are given at the end).

FUELS AND FUEL BURNERS. By K. Steiner. McGraw-Hill Book Company, Inc., New York, N. Y., and London, England, 1946. 394 pages, illustrated, $8^1/_2$ by $5^1/_4$ inches, cloth, $5. The nature, occurrence, and properties of fuels are treated from the viewpoint of domestic and commercial heating. Considerable space is devoted to the design, construction, installation, and operation of stokers, oil burners, and gas burners used in heating plants of residences, commercial buildings, and moderately sized steam plants. A special chapter on wood fuel is included, prepared by the United States Forest Service, and there is a rather complete discussion of automatic control methods and apparatus for heating systems, including both conventional electric and recent electronic types.

TABLES OF FRACTIONAL POWERS. Prepared by the Mathematical Tables Project under the sponsorship of the National Bureau of Standards and the Work Projects Administration for the City of New York and completed with the support of the Office of Scientific Research and Development, L. J. Briggs, director, and A. N. Lowman. Columbia University Press, New York, N. Y., 1946. 486 pages, tables, $10^3/_4$ by $7^3/_4$ inches, cloth, $7.50. The present volume of this steadily expanding series is a compilation of tables of decimal and fractional powers. In part I the values of A^x, for fixed bases and variable exponents, are given to 15 decimal places for 2-digit decimals of A and x. In part II the function X^a, for variable bases and the frequently occurring exponents $\pm^1/_2$, $\pm^1/_3$, $\pm^2/_3$, $\pm^1/_4$, $\pm^3/_4$, also are tabulated to 15 places. As usual, there is a bibliography of similar tables. In the foreword to the volume various problems are suggested, the solution of which is facilitated by the use of the present tables.

TABLES OF THE BESSEL FUNCTIONS OF THE FIRST KIND OF ORDERS ZERO AND ONE (Annals of the Computation Laboratory of Harvard University, Volume 3). TABLES OF THE BESSEL FUNCTIONS OF THE FIRST KIND OF ORDERS TWO AND THREE (Annals of the Computation Laboratory of Harvard University, volume 4). Harvard University Press, Cambridge, Mass.; Geoffrey Cumberlege, Oxford University Press, London, England, 1947. No pagination, tables, 11 by 8 inches, cloth, $10.00 each volume. Continuing a series of publications by the Harvard Computation Laboratory, these two volumes present detailed tables to 18 decimal places for a range of argument from 0 to 100, with an argument interval of 0.001 up to 25 and of 0.01 above 25. The volume covering the orders zero and one contains also an introductory discussion of Bessel functions, a description of the computational techniques, and the method of interpolating within the tables. The computation was done by the automatic sequence controlled calculator, the operation of which was described in volume I of the series.

TABLES OF SPHERICAL BESSEL FUNCTIONS, Volume 1. Prepared by the Mathematical Tables Project, National Bureau of Standards. Columbia University Press, New York, N. Y., 1947. 375 pages, tables, $10^3/_4$ by 8 inches, cloth, $7.50. In the theoretical analysis of wave motion, solutions of various coordinate systems are necessary, and in certain ones Bessel functions are involved having orders equal to one-half an odd integer. The present volume provides tables to seven or more significant figures for the spherical Bessel functions of orders $\pm(n+^1/_2)$ where $n=0$ to 13 with an interval of 1, and for a range of X from 0 to 10 with intervals of 0.01 and from 10 to 25 with 0.1 intervals. The customary detailed explanatory introduction is included, and a list of the previous publications of the series is appended.

ELEMENTARY VECTORS FOR ELECTRICAL ENGINEERS. Second edition. By G. W. Stubbings. Sir Isaac Pitman and Sons, Ltd., London, England, 1945. 110 pages, diagrams, tables, $7^1/_2$ by 5 inches, cloth, 6*s*/6*d*. This practical little volume emphasizes fundamentals and devotes the first two chapters to explaining the representation of a-c quantities by graphical vectors. Chapter III contains a detailed elementary treatment of the graphical solution of 3-phase problems, and the following two chapters deal with the concept and applications of vector algebra. A short, final chapter discusses the geometrical meaning of hyperbolic functions.

PAMPHLETS • • • •

Federal Communications Commission 12th Annual Report Covering the Fiscal Year of 1946. Superintendent of Documents, Government Printing Office, Washington, D. C., 20 cents.

The Use of Research by Professional Associations in Determining Program and Policy. By E. L. Brown. Russell Sage Foundation, New York, N. Y., 1946, 39 pages, 25 cents.

Symposium on Testing of Bearings. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 1947, 72 pages, $1.50.

Home Food Freezers, Refrigerating Engineering Application Data—Section 37. By R. H. Bishop. *Refrigerating Engineering*, 40 West 40th Street, New York 18, N. Y., 12 pages, 30 cents.